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PHYSICAL AND CHEMICAL

ESSAYS;

TRANSLATED FROM THE ORIGINAL LATIN OF

SIR TORBERN BERGMAN,

KNIGHT OF THE ORDER OF WASA, PROFESSOR OF
CHEMISTRY AT UPSAL, &c. &c. &c.

By EDMUND CULLEN, M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS
AT DUBLIN.

TO WHICH ARE ADDED

NOTES AND ILLUSTRATIONS,

BY THE TRANSLATOR.

VOL. I.

Quam ob rem, si qua est erga Creatorem humilitas, si qua operum ejus re-
verentia & magnificatio, si qua caritas in homines, si erga necessitates &
ærumnas humanas relevandas studium, si quis amor veritatis in naturali-
bus, & odium tenebrarum, & intellectus purificandi desiderium ; orandi
sunt homines iterum atque iterum, ut missis Philosophiis istis volaticis &
præposteris, quæ hypotheses thesibus anteposuerunt, & experientiam cap-
tivam duxerunt, atque de operibus Dei triumpharunt, submisse, & cum
veneratione quadam, ad volumen creaturarum evolvendum accedant ;
atque in eo moram faciant, meditentur, & ab opinionibus abluti & mun-
di, caste & integre versentur—In interpretatione ejus eruenda nulli operæ
parcant, sed strenue procedant, persistant, immorentur.

<div style="text-align: right">BACO DE VERULAMIO.</div>

O THE

ILLUSTRIOUS

ROYAL SOCIETY OF

LONDON,

THIS FIRST VOLUME OF

E S S A Y S

IS DEDICATED,

AS A PROOF OF RESPECT,

BY THE AUTHOR,

WHO HAS BEEN A FELLOW

FIFTEEN YEARS.

UPSAL, 1779.

TRANSLATOR'S

PREFACE.

TO enlarge on the literary abilities of the illuftrious Author of the following work, would be unneceffary: an affemblage of philofophical qualifications, very rarely found united in one perfon, has long fince fufficiently eftablifhed his reputation. But among the many endowments of this great philofopher, none is more confpicuous than the anxious concern he every where difcovers for the advancement of human happinefs, and the earneftnefs with which he applies the great powers of his mind to fuch points as may be immediately applicable to the ufes of life. He defpifes barren and unproductive
fpeculation ;

fpeculation ; he confiders fcience as defira-
ble only fo far as it is beneficial, and
proves himfelf, upon every occafion, not
only the Teacher, but the Friend of man-
kind.

Works like thofe of Mr. Bergman fhould
have an univerfal circulation ; they are
written not to the fcholar alone, but to the
artift, to the manufacturer, and to the world
in general. In prefenting the following
pages, therefore, to the Englifh Reader, the
Tranflator flatters himfelf he is acting in
perfect conformity with the fentiments of
the author, and the duty which, as an in-
dividual, he owes to the community.

As the Author writes chiefly to thofe
converfant in chemiftry ; and as it requires
more than a moderate acquaintance with
fome of the lateft difcoveries, to be able to
follow him through the whole of the work ;
it has been judged neceffary to add a few
explanatory notes, fuch as may render the
book ufeful to thofe who are only ac-
quainted with the elements of the fcience.

An

An Appendix is accordingly fubjoined to each volume, which, though by no means neceffary to the accomplifhed and experienced chemift, will, it is hoped, prove confiderably ufeful to the general run of readers, and thofe who are but moderately fkilled in the knowledge of the chemical principles and art.

Mr. Bergman, in his experiments, has employed the Swedifh thermometer : and it has not been thought expedient to reduce the temperatures, fo afcertained, to Fahrenheit's fcale in the body of the work, becaufe the degrees upon the Swedifh thermometer are not reducible to integral numbers upon that of Fahrenheit ; but, for the accommodation of fuch as chufe to compare them, a plate is inferted, containing the Swedifh and the French thermometers, together with that of Fahrenheit, which is at prefent univerfally employed in England.

The Swedifh meafures being alfo fo adjufted that they are not reducible exactly

to thofe of England, have been fuffered to
ftand as in the original ; but a table is
given, which contains thefe weights and
meafures accurately reduced.

ADVER-

ADVERTISEMENT.

THE great distance of the translator,
obliged the publisher to call in the assistance
of another person to superintend the press.
That person, being unacquainted with the trans-
lator's design of adding annotations at the end
of the volumes, was induced to add a few in-
considerable observations, such as his recollec-
tion could furnish, during an hasty perusal of
the MS. He, moreover, thought, that the
addition of M. De Morveau's notes would be
acceptable to the English reader. He accord-
ingly has selected such as afford any new views
of the facts related by the author, or supply
any experiment by which the text is illustrated.
He has omitted several that did not seem to
contain much useful information. That no
blame might be imputed to the translator, on
account of these additions, he has been careful
to distinguish those of M. De Morveau by his
name: his own by the letter B. Those mark-
ed C. belong to the translator; who has been
obliged, on account of some domestic interrup-
tion, to defer the greater part of his remarks
to the end of the second volume; which will
appear without delay. The author's notes and
references are without a signature.

CON-

CONTENTS.

I. Of the AERIAL ACID. p. 1.

Quid verum — — curo & rogo, & omnis in hoc sum.
HOR.

This Diſſertation was read in 1774, before the Royal Academy of Sciences at Upſal; and the year following it was printed in the 2d vol. of the New Tranſactions.

II. Of the ANALYSIS of WATERS. p. 91.

Neque vero negligentiorem ſe circa aquarum facultates cognoſcendes exhibere convenit. Quemadmodum enim guſtu differunt, & pondere ac ſtatione, ſic quoque virtute aliæ aliis longe præſtant.   HIPPOCRATES.

The firſt ſeven ſections of this Diſſertation were publicly defended by J. P. Scharenberg of Stockholm, on the 26th of June, 1778.

III. On the WATERS of UPSAL. p. 193.

Tales funt aquæ, qualis terra per quam fluunt.   PLINIUS.

The part of this Differtation relative to the Mill-
fpring, was publifhed in Swedifh, after having been de-
fended by P. Dubb, of Weftrogothia.

IV. On the ACIDULOUS SPRING in the PARISH of DENMARK. p. 210.

Jufta confeffione, omnes terræ quoque vires aquarum funt beneficii.
Quapropter ante omnia ipfarum potentiæ exempla ponemus.
Cunctas enim quis mortalium enumerare queat ? PLINIUS.

This Differtation was publicly defended by C. H.
Wertmüller, of Stockholm, on the 15th of December
1773.

V. Of Sea-Water. p. 226.

Mari late patenti faporem incoqui falis, quia exhaufto inde dulci tenuique, quod facillime trahat vis ignea, omne afperius craffiufque linquatur : ideo fumma æquorum aqua dulciorem profundam. PLINIUS.

This Effay was printed in the Stockholm Tranfactions for 1777.

VI. Of the Artificial Preparation of cold medicated Waters. p. 232.

Si quid novifti rectius iftis Candidus imperti, fi non, his utere mecum. HORATIUS.

This Differtation was inferted in the Stockholm Tranfactions for 1775 ; it was written in Swedifh. I have feen a Danifh Tranflation.

§ 5. *Analyfis*

VII. Of the ARTIFICIAL PREPARATION of HOT MEDICATED WATERS. p. 280.

Emicant benigne passimque in plurimis terris, alibi frigidæ, alibi calidæ, alibi junctæ. PLINIUS.

This Differtation was inferted, in Swedifh, in the Stockholm Tranfactions for 1778.

§ 4. *Dif-*

VIII. Of the ACID of SUGAR. p. 304.

Magni omnino res fuit, naturæ latebras dimovere, nec contentum ejus conspectu introspicere & in Deorum Secreta descendere.
SENECA.

This Differtation was defended, on the 13th of June 1776, by J. A. Arvidffon, now mafter in philofophy, lecturer in chemiftry, and a very dextrous experimenter.

a 4.   § 21. *Saccha-*

IX. Of the PREPARATION of ALUM.
p. 336.

*Intrandum est in rerum naturam, & penitus, quid ea postulat,
pervidendum.* CICERO.

This Differtation was defended, on the 1ft of April
1767, by G. Suedelius. It was tranflated into Ger-
man, but I have not yet feen the tranflation.

X. Of

X. Of Antimoniated Tartar. p. 395.

Paucis utatur Medicus remediis, iisque selectis.

This Dissertation was defended by J. A. Level, on the 22d of December 1773.

XI. Of Magnesia. p. 423.

Opinionum commenta dies delet, judicia naturæ confirmat.

CICERO.

This Dissertation was defended by C. Norell, on the 23d of December 1775.

§ 9. *Ar-*

O F

OF THE

INVESTIGATION

OF

TRUTH.

THE great difficulty attending the investigation of truth, must be known to every man who has ever seriously attempted it. *Involutam veritatem in alto latere*, was long since observed by the experienced Seneca.

With respect to such historical facts as are remote from our times, modern scepticism frequently exceeds all bounds, and determines arbitrarily what are to be considered as fictions, what as misrepresentations, and what as omissions. But we shall soon cease to wonder at this; for if we undertake, on the faith of others, to explore facts, which, even with respect both to time and place, are at hand, and almost under our immediate inspection (especially if we wish to learn the causes, motives, and connections of actions and circumstances)

we

we are often confounded by the moſt con-
tradictory narrations, infomuch that we have
occaſion for opportunity, and laborious
ſtudy, muſt diveſt ourſelves of preconceived
opinions, and be unbiaſſed by any intereſted
motives, in order to ſolve a number of dif-
ficulties, which owe their origin partly to
ignorance, partly to negligence, and not
unfrequently to deliberate malice. Should
a number of hiſtorians even agree concern-
ing a fact, yet the different defcriptions of
it will, to a certain degree, exhibit the cha-
racters of the refpective authors :—thus,
while one relates an action with the moſt ex-
travagant encomiums, another will detract
from its real merit—a third, by ſome oblique
inſinuation, caſt ſuſpicion upon the motive of
it—and a fourth reprefent it as a crime of
the blackeſt dye. But to quit this line of
enquiry.—It may be expected that we ſhould
find things otherwife in phyfics ; and that
though we may not be able to dive into the
thoughts of men, the phænomena exhibited
by nature would be liable to no ſuch am-
biguity.

So indeed it might feem, did not daily ex-
perience fully evince the contrary. Among
the moſt celebrated expounders of nature,
how many diviſions have there been ? how
many fchifms ? and what numbers do we
find fpringing up every day ?

But when we examine thefe difputes
more minutely, we ſhall find that they re-

late not fo much to facts, as to explanations. The labour of the natural philofopher is chiefly employed in endeavouring to difcover the means and the methods made ufe of by Nature in her operations (that is, caufes and their connections) and from thence to form what is called a theory; and upon this point has arifen wonderful diffention.

Des Cartes, affuming matter and motion, and thus beginning *ab ovo*, conftructs the world, imagines certain forms and affections of bodies, and, led away by a fublime imagination, connects and demonftrates mechanically, *a priori*, every phænomenon and every operation.—A ftupendous work indeed, were it but conformable to the fyftem of nature, which it undertakes to explain; but, upon comparifon, fo great a difagreement appears, that in circumftances where, according to the principles of the inventor, the moft powerful caufe is operating, there, in reality, is the fmalleft effect produced; and reciprocally. This whole imaginary ftructure, therefore, being reared without foundation, has neceffarily fallen to ruin.

The immortal Newton next appeared.— This illuftrious perfonage, rendered cautious by the failure of his rafh predeceffor, acknowledges that a conception of the theory of creation exceeds human powers: he therefore follows the inverfe method.—He firft folicitoufly collects facts; thefe he examines

with

with accuracy, and compares with acutenefs: hence he deduces the laws of nature, and, from effects well eftablifhed, he infers their caufes. Thus he proceeds, more flowly indeed, but more fecurely; and though his method be tedious, yet it is continually leading to further difcovery. An edifice like this, built on a folid foundation, becomes the more firm the higher it is raifed.

Although at prefent it is univerfally agreed, that nothing is known concerning bodies *a priori*, but that their nature and different properties muft be difcovered *a pofteriori*, by obfervation and experiment; neverthelefs, in practice there are ftill not a few who, if not publicly, at leaft privately, incline to Cartefianifm :—I call it Cartefianifm, not becaufe that method of reafoning was invented by Des Cartes (for in the moft remote periods of time there have been philofophers who, confiding too much in their own ftrength, have expected to be able to difcover the nature of things by abftract meditation); but I employ the names of Des Cartes and Newton as affording the moft ftriking examples of the different methods of philofophizing.

I have faid that a tendency to Cartefianifm ftill fubfifts; and upon attentive confideration it will not appear wonderful that the human mind fhould delight to indulge in this method; for, on the one hand, the way of experiment is expenfive, troublefome, and
tedious;

tedious; all minds, therefore, are not capable of enduring it; many are without the proper inftruments; others want the neceffary dexterity; but the moft univerfal defect is that of patience and perfeverance, fo that if the experiment does not at once fucceed, it is abandoned in difguft. Man in his ordinary ftate feems by nature prone to indolence. On the other hand, the contemplative method favours the defire of knowledge; by pretending to unlock the fecrets of nature with eafe and expedition, it foothes the natural rage of explaining all things; and, by fuppofing every thing acceffible to the human intellect, adminifters pleafing flattery to vanity and arrogance.

At prefent, however, the neceffity of experiment appears fo obvious, that no one can deny it, without expofing himfelf to ridicule. It is therefore acknowledged, but with a tacit limitation. A number of experiments, made during a fucceffion of ages, is collected; and an accurate and attentive confideration of them is thought fufficient to unravel the chain of caufes. Thus a philofopher at his table, furrounded with books, undertakes to penetrate the arcana of nature, and to deal out truths as if by infpiration; and, without a laboratory, without a fuitable apparatus, without expence, trouble, or danger, pronounces concerning fubftances, which, far from examining as he fhould, he has never fo much as feen. Nor has this invention

vention even the recommendation of no-
velty ; for, many ages fince, Ariftotle
eftablifhed experiment and reafoning as
the two foundations of natural philofo-
phy ; but by means of the latter he mifer-
ably corrupted the former. In this way,
at prefent, the purity of truth is cor-
rupted by preconceived opinions concern-
ing the genefis and metamorphofis of mat-
ter.—Opinions fuch as thefe, if modeftly
and candidly propofed as conjectures, might
be ufeful, by giving occafion to new experi-
ments ; but are of the moft pernicious ten-
dency when obtruded as axioms; when they
wreft fuch experiments as contradict them
to a conftrained agreement ; or, if that
cannot be done, impugn the truth of the
experiments. Another evil has originated
from favourite hypothefes ; namely, experi-
ments mutilated, and not to be relied on.
He who is governed by preconceived opi-
nion, may be confidered as a perfon viewing
objects through coloured glaffes, each af-
fuming a tinge fimilar to that of the glafs
employed. The flighteft and moft vague fi-
militudes, if agreeable to the fyftem, are
fufficient, nay, afford arguments of the
greateft weight; while differences of the
moft ftriking nature are difregarded as alto-
gether nugatory.

The time which is employed in difcuffing
thefe trifles would furely be better appli-
ed in experiment and obfervation ; a la-

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bour by which truth may be made to shine
forth in full lustre, and due honour be given
to science, which now (tarnished by contra-
dictions and dissensions) is, if not totally
despised, at least suspected by those who are
incapable of deep enquiry.

Add to this, that; even in natural philo-
sophy, the turbulent passions of the mind are
not always idle : sad experience has shewn
us the most beautiful inventions brought in-
to contempt; and the highest merit blasted,
by malignant clamour. But our business is
not with those who are wilfully blind to
truth ; to argue with such would be to tell
tales to the deaf.

Since then truth is, or at least ought to
be, the end of every investigation, to obtain
this end with ease and expedition—*hoc opus,
hic labor,*—I think it therefore necessary, at
the beginning of this Collection of Essays,
to explain to the reader the principal rules
which, in the progress of them, I laid down
for myself. In the examination of any body,
two circumstances are chiefly to be consi-
dered, namely, *the composition of that body,*
and *the explanation of phænomena.*—These
two we shall consider separately.

I. (A) *In investigating the principles of a
body, we must not judge of them from a slight
agreement with other known bodies, but they
must be separated directly by analysis, and that
analysis must be confirmed by synthesis.*

It is well known that bodies by compo-
sition acquire new properties, which did

b   not

not appear in any of the component parts
feparately ; and on the contrary, fome of the
original properties decay, or even difappear ;
hence it appears how little analogy is to be
trufted to.

Thus, although terra ponderofa and mag-
nefia agree with lime in this particular, that,
when united with aerial acid, they effer-
vefce with other acids ; and that, when it is
expelled, they become cauftic, we are not
hence to conclude that lime is contained in
thofe fubftances : this analogy is certainly a
loofe one, and, when rightly confidered, only
fhews that the aerial acid poffeffes the pro-
perty of uniting with a variety of fubftan-
ces, and that by its prefence caufticity is
repreffed.   If we were to deduce conclu-
fions from this analogy, then the alkaline
falts muft contain lime, as they alfo effer-
vefce with acids, and in fimilar circum-
ftances exhibit a much greater degree of
caufticity.

 The hiftory of the learned world fhews us
the abfurd arguments which were formerly
made ufe of againft the exiftence of the fof-
file alkali, which is now acknowledged by
every one to exift diftinct from the vegetable
alkali, inafmuch as, when combined with
the acids, it never fails to produce falts of a
different fort. In the fame manner terra pon-
derofa and magnefia, with acids, yield falts
very different from thofe produced by lime
with the fame acids : we may therefore con-
clude thefe to be diftinct fubftances.

That

That perhaps they contain a lime some-how changed, I will readily acknowledge, as soon as lime can be extracted from them, or they can be converted into lime. Conjectures the most plausible are yet at a distance from truth; and, upon close examination, are frequently found altogether repugnant to it.

What has now been said holds, *mutatis mutandis*, of aerial acid and the acid of sugar; as also of nickel, cobalt, and manganese.

In general, any body which differs in properties from every other, and can be always had *similar to itself*, I consider as a different and distinct body, although it be produced by another known body; for properties new and constant cannot spring up, unless the primitive be changed by the addition or subtraction of some principle, in which case it is not the same body as before.

(B) *Analysis should chiefly be conducted in the humid way.*

I do not deny, but that the dry way may sometimes be useful, and ought to be employed—but in most cases fire tends rather to confound than to separate different substances.

Some contend that matters extracted by menstrua are changed; and that they had existed in the decomposed body in a state very different from that in which they are found after the decomposition: but let us not rest upon vague assertion, let us enquire

b 2 into

into the truth by experiment, and our doubts
will foon vanifh :—let us diffolve a given
quantity of pure chalk in marine aci. let
this again be precipitated by a fixed alk i. ;
and if this alkali be mild, the chalk is re-
covered entirely fimilar to itfelf in proper-
ties and in weight : but if the alkali em-
ployed be cauftic, not more than half the
weight is obtained, and the precipitate agrees
with lime burned and flacked ; for it is
foluble in water, and raifes no effervefcence
in acids.   This experiment, if repeated an
hundred times with the fame chalk, will
always afford the fame product : the fame
thing is true of terra ponderofa and mag-
nefia, and alfo pure clay, of which the
weight however is fcarce fenfibly altered
by a difference in the precipitant—the fame
holds in the other acids.   Let us now dif-
folve fome metal, precipitate with a fixed
alkali, and we fhall have a calx of that me-
tal ; but if we precipitate with another me-
tal we fhall recover the diffolved metal itfelf,
only very minutely divided.   Mild alkali
in certain cafes produces a much heavier
calx than the cauftic ; namely, when the
calx abforbs the aerial acid : befides, the
different acids occafion, in this cafe, no other
difference than a greater or lefs privation of
phlogifton.   Thefe things, of which no one
converfant in chemiftry is ignorant, being
known : let us fuppofe either lime, mag-
nefia, clay, or iron, extracted by any acid
menftruum ; I afk, can we reafonably doubt
                                     whether

whether thefe fubftances actually exifted in the body fubjected to the experiment, or not?—from the qualities of the integrant body it will eafily be judged whether thefe have entered into its ftructure, mild or cauftic; in the form of a calx, or in that of a metal.

Upon this occafion I muft mention the inveterate error concerning the origin of vegetable alkali by fire: the filly and abfurd reafons on which they denied the prior exiftence of that falt, may now be retorted upon the authors.

(c) *Such experiments fhould be inftituted as are adapted to the difcovery of truth.*

Light is thrown upon a fubject not by the multitude but by the quality of experiments : moft commonly many different points are to be illuftrated, and then the experiments fhould be varied according to circumftances, fo as clearly to afcertain the point in queftion.

For example, in examining the mineral fluor, one queftion arifes concerning the acid inhering in it, another concerning the bafis. To obtain the firft, pure vitriolic acid muft be applied in lefs quantity than is fufficient to expel it all, and a degree of heat applied lefs than what is fufficient to volatilize the vitriolic acid. In examining the bafe, the fire muft be more intenfe, and a large quantity of vitriolic acid poured on, that no part may efcape its action, which, mixed with the bafe, might obfcure its true nature;—thus, unlefs the operations and the

b 3

means

means be adapted to the end propofed, we only every day accumulate miftakes.

(D) *Experiments fhould be made with the utmoft poffible accuracy.*

Experiments, which are only carelefsly and flightly obferved, frequently either do not illuftrate the truth, or eftablifh errors. By weight, by meafure, and other fit means, all the principal circumftances fhould be fettled, and all the phænomena carefully obferved : with refpect to facts, indeed, which are collected by experiment, no dif- pute can arife, as they may at pleafure be appealed to, and confidered in every point of view with fufficient care. The cafe is otherwife with thofe circumftances which depend folely upon the operations of na- ture ; for thefe, if the fit time be neglected, do not again occur, but accidentally, or perhaps after an interval of years. " *Fronte capillata, poft eft occafio calva.*" In many cafes, however, imitation may be able to diminifh that interval.

I am almoft afhamed to relate, that I knew a chemift who confidered thermome- ters, and fuch inftruments, as phyfical fub- tleties, fuperfluous and unneceffary in a la- boratory. It is beyond a doubt, that the moft minute circumftances have their effi- cient caufes ; and thefe caufes, for the moft part, fo interwoven with the more powerful ones, and fo moderate their efficacy, that without the former the whole effect cannot be appreciated. In natural philofophy no

<div align="right">·obfervations</div>

obfervations are trivial, no truths infignificant : that which to us is barren is often fo for this reafon only, that we do not fufficiently know, nor fufficiently examine it. How many millions had ufelefsly beheld the falling of a pear ; yet, to Newton, this moft common of all phænomena fuggefted the theory of gravitation.

(E) *The experiments of others, particularly the more remarkable ones, fhould be candidly reviewed.*

We fhould never diftruft the experiments of authors of credit ; but I hold it ufeful to have new inventions confirmed by many witneffes in different places, which opens a wide field to induftry.

It muft be confeffed, that many things occur which are more clearly and better underftood by being feen, than by the moft exact defcription. In repeating any of Margraaf's experiments, I never entertained even the fmalleft doubt of the event ; the accuracy, the dexterity, and found reafoning of that chymift, are known to every one inftructed in thefe matters ; neverthelefs, I have repeated many of them, not without advantage. He who at his defk meditates on the faccharine acid, readily concludes it to be fugar diffolved in the nitrous acid, and afterwards cryftallized ; but, better inftructed on making the experiment, he changes his opinion, and learns not to give judgment rafhly upon the experiments of others.

One thing particularly neceffary is candour,

dour, in obferving with equal eye thofe facts which controvert our opinions, and thofe which favour them. It is well obferved, by the celebrated Morveau, that we never profit more than by thofe unexpected events of experiments which contradict our analogies and theories : it often happens, however, that he who fees the better follows the worfe. Thus he who denies that the earth of vegetables, feparately taken, is not a compound body, yet grants that a part of it is foluble in acids, confutes himfelf with his own argument ; for of an homogeneous mafs either the whole or none muft be taken up.

II. The phænomena of a body, either confidered by itfelf, or in reference to other bodies, have their foundation either in the body itfelf, or in external circumftances: the explanation of thefe, then, muft be fought for,—" *bene fcire, eft per caufas fcire* ;" thefe being rightly known, the nature and properties are clearly underftood, and may be moulded to our wifh. The greateft care, however, muft be taken not to embrace falfhood for truth—therefore,

(A) *In the inveftigation of caufes, we muft begin by phænomena, fufficiently varied, and well obferved ; and proceed in order, from proximate caufes to the more remote.*

The quantity and quality of a caufe are to be judged from its effect ; hence the better that is known, the more nearly can thofe be determined. This way is extreme-

ly

ly laborious and troublesome, and, besides, very tedious; insomuch that we are often found to confess the cause of this or that phænomenon to be yet unknown: but the laws by which a cause is governed in its operations, being once established, we are at liberty, in many cases, to assume the cause, as if known; and I had rather, with Newton, ingenuously confess my ignorance, and know few things, but these certain and determinate, than, with Des Cartes, explain every thing upon forged or false principles. Cicero long since said, " *præstat naturæ voce doceri quam ingenio suo sapere.*"

By how trifling an appearance, if it be a pleasing one, we may be deceived, the following example will shew:—it is known, that lime, well burned, has lost the property of effervescence with acids. This phæ-nomenon is troublesome to many who deny the existence of aerial acid. At length, however, an evasive expedient was supposed to be discovered, namely, if burned lime be put into highly concentrated acids, a visible effervescence is said to take place, which, when the acids are weak, cannot be seen, as the substance, being dried by the fire, readily absorbs them. In order to clear up this mistake, it is only necessary to observe the phænomena with accuracy:—let a small glass vessel be filled with nitrous acid, throw into it a piece of chalk, immediately innumerable bubbles are emitted from its whole surface, which continue while a single par-

ticle

ticle remains vifible ; during this violent
agitation a thermometer dipped into the
glafs fhews not the flighteft alteration of
temperature (*a*) : whether the acid be di-
luted

(*a*) M. Morveau, in a note, which I have tranflated
(fee p. 38) truly obferves, that when chalk is diffolved
in a concentrated acid, heat is produced. The author
himfelf *(Opufc.* vol. iii. p. 64.) fays, that calcareous
earth, while it was diffolving in nitrous acid, raifed the
liquor in the Swedifh thermometer from + 14° to + 20°,
and lime, not flacked, from + 14° to + 84°. He attri-
butes the miftake in the text to his having made the
experiment with too fmall a quantity of materials, and
having employed a thermometer not fufficiently fenfible.

In the fame note M. Morveau gives an explanation,
undoubtedly erroneous, as I have there obferved, of the
heat and cold produced in chemical experiments. Sir
T. Bergman has affigned the true theory in his third
volume. He has deduced it from the different quantity of
fpecific fire, or, according to his mode of expreffion, of
matter of heat, contained in different fubftances :—" The
menftruum," fays he, " deftroys the prefent aggregation of
particles, and a new compound is formed, which fome-
times fixes a greater quantity of the matter of heat than
the former compound ; in this cafe, in order to reftore
the equilibrium, the heat in the contiguous bodies muft
undergo a diminution, and the liquor in the thermometer
will of courfe defcend : if the new compound fixes a
fmaller quantity of the matter of heat, the furplus will
be let loofe, and flow into the contiguous bodies : when
the quantity of heat is the fame in both compounds
(which feldom happens) the thermometer will not be at all
affected."—Mr. Kirwan has lately given nearly the fame
explanation of thefe phænomena, in the Philofophical
Tranfactions. Evaporation muft be taken into the ac-
count : wherefore, in the laft cafe fuppofed by Profeffor
Bergman, the liquor in the thermometer muft fall a little.
Mr. Kirwan, if my memory does not fail me, intimates
this circumftance, but does not exprefsly mention it.

Profeffor Bergman, I think, in more paffages than one,
obferves, that the great difference of heat in a folution
of

luted or concentrated, the fame phænomena occur. Let now the experiment be repeated, only, inftead of crude chalk, let an equal piece, well burned, be ufed; let the acid be diluted, and at firft a very few bubbles appear, but foon fall; befides, in this cafe, a confiderable degree of heat is produced, fomewhat lefs than 100°. If the acid be fufficiently concentrated (but not too much) at firft, not only fmall, but even large and numerous bubbles arife, which, however, foon die away, and all vifible motion ftops, both

of aerated and cauftic calcareous earth, is a proof that this earth, when it yields its air, fixes a quantity of the matter of heat; but he who reflects how much of this active fluid muft be abforbed by the aerial acid, as it paffes from its folid to its fluid form, will eafily be perfuaded that this confideration will explain much of the difference. The fpecific fire in the compound of nitrous acid and calcareous earth is, doubtlefs, in both cafes equal.

Thofe who are acquainted with the ufual order obferved in printing books, know that prefaces, preliminary differtations, &c. pafs through the prefs laft. This circumftance obliges me to place here an obfervation which refers to page 48. I have there ventured to reject both the author's and the French annotator's hypothefes refpecting lime too much burned, and to offer another explanation. Since that note was written, the third volume of the Opufcula has fallen into my hands, in which I have found that the author himfelf has explained this phænomenon from the very fame fuppofition.—" It is moft probable," fays he, " that a ftrong heat, fuddenly applied, and long continued, occafions a kind of fufion of many particles lying on the furface, *moleculæ—fufionis fere more in ambitu coalefcere incipiant,* &c." The reader may now fafely refufe to admit the author's firft fuppofition, fince more mature confideration has induced him to reject it himfelf. B.

in the calcareous mafs and in the acid liquor. In this cafe, however, a very intenfe degree of heat is generated, which, if the piece be large, exceeds 100°.

From thefe phænomena, attentively con-fidered, an explanation will eafily and natu-rally be deduced. In the latter cafe, for in-ftance, fo much heat is produced, that the watery parts in contact with the burned chalk boil for fome moments; but when the acid is diluted, only a few air bubbles, which occupied the pores of the fpongy mafs, are difcharged by the expanfive power of the heat: in both, however, the motion is foon at an end. But, with the crude chalk, the motion continues until the chalk is totally diffolved;—this motion is called effervefcence, and muft carefully be dif-tinguifhed from ebullition.

(B) *A caufe, any how indicated by phæ-nomena, may for a while be affumed as true; and from it may be deduced the neceffary con-fequences, which, being feparately examined by fuitable experiments, either confirm or over-turn the pofition.*

This method has been often ufed to ad-vantage in mathematics, and ought to be applied in natural philofophy, as a teft for the examination of various hypothefes and conjectures; and we muft confefs, that a pofition, all the legitimate confequences of which are confirmed by experiment, may properly be admitted as true: in this cafe

we

we have a problem indeterminate, of which the unknown quantities are fought by experiment.

(c) *Befides, the caufe fhould, if poffible, fo be compared with the effect, that the exact relation may be difcovered, even as to quantity.*

By this it will appear, whether the caufe alone be adequate to the effect, or whether it has been affifted. An inftance of this kind occurs in the confideration of agriculture, where a queftion arifes concerning the ufe of water in vegetation.

Finally, *I aim at giving denominations to things, as agreeable to truth as poffible.*

I am not ignorant that words, like money, poffefs an ideal value, and that great danger of confufion may be apprehended from a change of names; in the mean time it cannot be denied that chemiftry, like the other fciences, was formerly filled with improper names. In different branches of knowledge, we fee thofe matters long fince reformed : why then fhould chemiftry, which examines the real nature of things, ftill adopt vague names, which fuggeft falfe ideas, and favour ftrongly of ignorance and impofition ? Befides, there is no doubt but that many corrections may be made without any inconvenience :—if, inftead of oil of vitriol, and fpirit of vitriol, we ufed the terms *concentrated vitriolic acid*, and *diluted vitriolic acid*, I think that no one would be thereby either confounded or mifled.

But

But in defcribing new fubftances, it is neceffary that names fhould be conformable to the nature of the fubftances. Thus, inftead of *fixed air*, I ufe aerial acid, becaufe that fluid is in its nature acid ; and not only poffeffes the fubtlenefs and elafticity of air, but either contains pure air, or fome of its conftituent principles ; for the pureft air that can be got, on the acceffion of phlogifton produced this fluid (the aerial acid) ; I could not therefore find out a name better adapted. Some think that this fubtile acid is the fame as phlogifticated vitriolic acid ; but whoever has feen and compared the two, cannot ferioufly defend that opinion.

Let me have permiffion to mention here an obfervation which feems to indicate the prefence of phlogifton in the aerial acid : —pure vitriolic acid cannot be refolved into a permanently elaftic fluid ; but, on the addition of phlogifton, an aerial fluid is generated (totally different from the aerial acid) which is not condenfed by cold, unlefs it touch water (*b*) : the fame is to be faid of

(*b*) We. have now much ftronger and more direct proofs of this hypothefis ; and the experience of every day feems to add to the number : 1 fhall not confider them here ; the laft Effay in the third volume will afford a more favourable opportunity. I have in contemplation fome experiments calculated to elucidate the queftion : if the refults fhall furnifh me with any information, I will there lay it before the public. In the mean time, experimental philofophers would be well employed in analyfing this acid : the folution of few problems

of the nitrous acid ; but the marine acid by
itfelf is refolvable into an aerial fluid. Now
as this laft acid contains phlogifton as a
proximate principle, as is demonftrated by
analytic and fynthetic experiments, it hence
feems to follow, that the aerial acid con-
tains the principle of inflammability : I
fay, *feems* to follow, for all things which
are like truth are not therefore true.

Thefe few reflections it was proper to
premife.   Let the fkilful and impartial de-
termine with what fuccefs I have fought for
truth in the following effays ; and whether,
as I endeavoured to avoid one rock, I have
not fplit upon another.

Moft of the effays contained in this firft
volume have already been publifhed fepa-
rately ; but, as the copies were foon dif-
perfed, and, moreover, as fome were written
in Swedifh, fome in Latin, and others in
French, I have undertaken, at the inftance
of my friends, and more efpecially fuch
as are foreigners, to collect them, and
tranflate into the common language of the
learned thofe which were written in other
languages. I have not difpofed them in the
order of the time in which they were print-
ed ; but I have rather endeavoured that the
preceding fhould illuftrate thofe which fol-

problems will throw fo much light upon the theory of
chemiftry.   If the aerial acid fhall be found to confift of
dephlogifticated air and phlogifton, Mr. Scheele's doc-
trine of heat muft fall to the ground ; if not, it will be
difficult, in the prefent ftate of chemical knowledge, to
find arguments fufficient to overthrow it.   B.

low.

low. I have, however, mentioned in a note the time of the firſt publication of each eſſay.

In the firſt volume I have inſerted thoſe eſſays which relate to ſalts ; in the ſecond, thoſe which refer to mineralogy and metallurgy ſhall be comprized ; the third, ſhall contain the doctrine, of attractions, together with the analyſis of ſome organized bodies ; the fourth, various matters relative to natural philoſophy and natural hiſtory ; and in the following I will publiſh, if God grant me life and ſtrength, other chemical eſſays.

I ſhall be ſatisfied if the following experiments, which were inſtituted with all the accuracy and fidelity that circumſtances would permit, ſhall not be diſpleaſing to thoſe who with me ſeriouſly ſeek for truth. Of others, I neither deſire the praiſe nor fear the cenſure. I ſhall not be ſurprized if it ſhall appear that I have committed miſtakes ; but I wiſh they may be corrected as ſoon as poſſible. I myſelf will add, to the following volumes, whatever corrections or additions more accurate obſervation ſhall ſuggeſt to me. Thoſe who ſhall attempt to obſcure what is true, will find to their diſgrace, that it will ſhine with greater luſtre. Some things which in one place are barely mentioned, without any proofs being adduced, are fully proved elſewhere ; for I have been anxious to advance nothing raſhly. I therefore intreat thoſe who ſhall examine my aſſertions, not to reject them haſtily, but to conſider the foundation on which they reſt.

3

AERIAL ACID.

ABOUT the year 1770 I communicated my ideas concerning the nature and properties of that elastic fluid, which, under the title of Fixed Air, exercises the fagacity and induftry of the philofophers and chymifts of the prefent age, to my foreign correfpondents; among whom it is fufficient to name the celebrated Dr. Prieftly, who not only mentions my opinion in the Philofophical Tranfactions for the year 1772, but, in a new edition of his excellent Obfervations on Air, has confirmed it by feveral fine experiments. The Royal Academy of Sciences at Stockholm have, it is true, inferted in their Tranfactions for the Year 1773 a fhort treatife of mine upon that fubject; however, as the doctrine contained in it deferves the moft accurate examination, and the moft minute and attentive confideration, I here re-publifh it, confirmed by experiments and obfervations.

B   § 1. *What*

§ 1. *What is to be underſtood by the term*
         " *Fixed Air.*"

For the purpoſe of avoiding ambiguity, it
is neceſſary to begin by explaining certain
terms. The term " Fixed Air" has been uſed
in two acceptations, one more extenſive,
the other more limited ; in the former it is
taken for every elaſtic fluid ſet at liberty
during the decompoſition of bodies, by
whatever means it is extricated, and what-
ever be its nature. Theſe fluids, however,
are far from being all of the ſame kind, for
ſome are very ſuſceptible of inflammation,
others inſtantly extinguiſh fire. The reſt
differ not a little from each other, but all
agree in this, that although very like to
common air in many properties, yet they
appear to have exiſted as it were fixed in
bodies, and deprived of their elaſticity,
which they do not recover until the inſtant
of their extrication ; hence they have gene-
rally been diſtinguiſhed from common air
by the epithet *fixed*. If this denomination
muſt be retained, I do not deny but that
the general ſignification above explained
agrees perfectly well with it ; but the other
more reſtricted ſenſe has for ſome time ob-
tained, and as it is in general uſe, I am un-
der the neceſſity of adopting it in the fol-
lowing Treatiſe, denoting by it only that
ſpecies of air which is found in alkaline
earths and ſalts, extricable by fire or acids,
                                                    and

and which issues in great quantities from many vegetables during fermentation. This, when properly depurated, possesses always the same qualities, and, as it evidently exhibits the properties of an acid, I call it (conformably to its nature) the Aerial or Atmosphæric Acid, the reason of which denomination will hereafter appear, particularly in §. xxii. and xxiii.

That species of air which suddenly destroys animals, and is entirely unfit for respiration, is called Mephitic Air, such as is found in the cavern near Naples, called Grotto del Cane, and in many others. This pernicious quality is common to most elastic fluids which have been fixed in bodies ; so that this denomination is nearly the same with that of *Fixed Air*, taken in the more extensive sense.

§. ii. *How pure Fixed Air is procured.*

There are three different methods of obtaining fixed air :—It may be expelled with effervescence by a stronger acid (*a*) ; it may be expelled by a sufficient degree of heat ; or finally, it may be extricated by fermentation. We shall describe all these methods in order.

(*a*) The author in this place considers fixed air as an acid, which may be expelled from the substances with which it is united, by means of a stronger acid ; and this extrication of fixed air is attended with an effervescence. C.

To

To the orifice A (Pl. 1. fig. 2.) of a glass phial A B, let there be cemented, so that no air can escape, the crooked glass tube E F G ; let the vessel be nearly half filled with distilled water ; let there be added pellucid calcareous spar, coarsely powdered, until it almost rises to the surface of the water C D, through the funnel o, cemented to the orifice L, and imperfectly closed by the glass rod P ; let concentrated vitriolic acid fall in drop by drop ; upon which innumerable bubbles will instantly arise from the calcareous particles : in the mean time let the orifice G of the tube remain open, until the atmosphæric air contained in the upper part of the bottle, and in the tube, be entirely expelled by the more ponderous fluid discharged (§. XXIV.) ; let the orifice G then be introduced under the mouth of the vessel H G, filled with water, and inverted with its mouth beneath the surface of the water in the vessel M N.

This being done, numerous bubbles will rise into the vessel H I, which collecting above, by degrees force out the water. When the water is entirely forced out from the vessel H G, the extremity of the tube is to be removed, the bottle close stopped under water (b), and the air conveyed from it

(b) The design of passing the elastic fluid from one vessel to another, is merely to free it from vitriolic acid, whose attraction for water is so great, that, during its passage, it quits the fixed air, and unites with the water. C.

3   into

into another veffel Q R, of a fize fomewhat
fmaller : as a portion of the air is abforbed
in its paffage through the water, the ae-
rial acid thus collected in Q R, will cer-
tainly be found pure, unlefs, perhaps, mix-
ed with a fmall portion of atmofphæric
air, which can fcarcely have been compleat-
ly expelled by the fluid extricated during
the effervefcence. If the vapour fhould
contain any vitriolic acid, this laft will cer-
tainly remain in the water, at leaft after
the fecond paffage through it.

If, in place of the vitriolic, the nitrous,
muriatic, or any other acid (fo diluted as
not to fmoak (c)) be applied with proper
care, the very fame kind of air is produced,
the ftrength and quantity of the acid muft
be fo regulated, that fcarcely any heat fhall
be generated. I avoid making ufe of chalk,
as it almoft always contains marine acid (d).

SECOND

(c) If the fmoaking, nitrous, or marine acid, be em-
ployed, it is obvious that thefe acids, being in this ftate
extremely volatile, will rife, in part, along with the fixed
air, which confequently will not be pure. The caution
againft heat is founded on the fame principle. C.

(d) If chalk containing marine acid be employed, the
heat which vitriolic acid generates on mixture with wa-
ter, will volatilize the marine acid, and confequently ren-
der the fixed air impure. C.

Mr. Morveau having let fall a few drops of a fo-
lution of filver and mercury in the nitrous acid into
diftilled water in which chalk had been boiled, obferved
that the former folution inftantly clouded the water, and
that by the latter a fmall quantity of yellow precipitate
was produced. I have repeated the experiment, with

SECOND METHOD.

Let a retort of green glafs, not above one inch in diameter, be provided, with a very flender neck ; let the body of the retort be filled with magnefia alba, and placed in a crucible furrounded with gypfum, and the whole apparatus be fet in a portable furnace contiguous to its fide, fo that the neck fhall not be expofed to the fire ; let a glafs tube be luted to the neck of the retort very clofe-ly, (fo as not to give exit to the elaftic fluid) and fo bended, that the aperture of the veffel H I, inverted in water, may be hung over the extremity G ; let the crucible then be made red hot, and fuffer the air bubbles to

the fame refult, upon one fpecimen of chalk ; but having boiled another in diftilled water, I found that neither folu-tion of filver nor the acid of fugar deftroyed the tranf-parency of the water. Mr. Duhamel has long fince re-marked, that " during the combination of quick-lime " with the mineral acids, a quick and penetrating vapour " is difcharged, which precipitates the folution of filver : " this circumftance, added to its odour, led him to fufpeɛt " that it was the marine acid." See Lavoifier's Effays. — In order to bring this fufpicion of Mr. Duhamel to the teft of experiment, I boiled fome quick-lime in water, and having precipitated the diffolved earth by means of fixed air, I filtered the water, and added folution of filver and acid of fugar, but the liquor was not rendered turbid by either of thefe tefts. It is natural to fuppofe that the marine acid generally contained in calcareous earth would be volatilized by calcination. That which I employed had been well burned : perhaps Mr. Duhamel's had not. If, therefore, this fuppofition be admiffible, his obfervation will coincide with that of Profeffor Bergman. B.

fly

fly off until the common air is diffipated ; then let the air which afterwards comes over be collected in the veffel H 1, as in the former method.

I make ufe of a fmall retort, both that the mafs contained may eafily acquire a due degree of heat, and that the quantity of common air lodged in its neck and the tube may be fmall : I chufe a glafs veffel, as thofe made of earth have often difappointed me, by giving paffage to the elaftic fluid through chinks fo fmall as not always to be dif-covered by the eye. Magnefia, when fcarce-ly ignited, emits its fixed air with eafe, whereas calcareous earth retains it with much greater obftinacy; fo that if the latter be em-ployed, a much more vehement fire is ne-ceffary : I furround the body of the retort with gypfum, that it may not flow by the violence of the heat, but, on the contrary, grow more refractory by the cementation, and acquire the properties of Reaumur's porcelain.

THIRD METHOD.

This method differs from the two for-mer, for here the elaftic fluid is produced by fermentation. It is nearly immaterial what fermenting mixture we employ, but I gene-rally make ufe of the following :—

In a bottle, of which the capacity is 350 cubic inches, I mix 20 oz. of fugar, and as much of good yeaft, with 200 cubic inches

of

of water ; in fix or feven hours, and in about
15° (e) of heat, the common air is generally
expelled ; I then adapt the orifice G of the
crooked tube to the mouth of the bottle H I,
and bubbles immediately rife. The fermen-
tation goes on equally well, if the tube be
at firft adapted to the neck of the bottle,
the accefs of air not being neceffary ; it is
fufficient that an exit be allowed to the elaf-
tic fluid, as I have often experienced.

It is neceffary to take care, in this as well
as the former methods, that the tube E F G
be not too long, as the difficulty of the pro-
cefs encreafes, in proportion to the quantity
of air to be removed : let us fuppofe this
refiftance = R, and the elaftic force of the
fluid generated at one time = E, it is manifeft
that if R = E there will be no room for ex-
panfion, and confequently no difengage-
ment can be effected, either by effervefcence,
by fire, or fermentation, as the following
experiment may ferve to fhew :—

Prepare a ftrong bottle, nearly full of
water, to which let chalk or cryftallized
alkali be added, let it then be filled with
any acid, and quickly and clofely ftopped :
at firft, indeed, a few bubbles appear, but
this appearance foon ceafes, and the mixture

(e) In the Swedifh thermometer the fpace between
the freezing point and the heat of boiling water is divided
into 100 deg. fo that 10 of thefe degrees are equal to
18 of Fahrenheit's fcale.   Wherefore 15°. = 27, and
27 + 32 = 59.   B.

remains clear, even for years, provided no exit is allowed to the elaſtic fluid, and ſuch a portion (ƒ) only be ſaturated, that the water can take up its fixed air ; but the very ſmalleſt aperture immediately excites a moſt violent effervescence.

The air which is collected by the ſecond and third methods may, like that got by the firſt, be waſhed (g) ; and by whichever of theſe methods (though ſo very different) it is obtained, it exhibits exactly the ſame properties.

§ III. *General Properties of Acids.*

Saline ſubſtances are uſually diſtinguiſhed from others by their ſapidity, and ſolubility in water. Thoſe which are ſpecifically called acids, exhibit very diſtinct characters, peculiar to themſelves, which are now to be enumerated ; of theſe the 1ſt, 6th, and 8th are common to other ſaline bodies, but in a mode and degree very different.

1ſt, They very readily unite with water ; 2d, they have an acid taſte ; 3d, they change the blue juices of vegetables to red ; 4th, they have a very ſtrong affinity with alkaline ſalts,

---

(ƒ) If ſo large a portion of the chalk or alkali be ſaturated, before the veſſel is cloſed, that the water is not able to abſorb the elaſtic fluid extricated by the ſaturation, the veſſel will burſt. It is neceſſary therefore to cloſe the veſſel very ſuddenly, or the experiment will not ſucceed. C.

(g) By paſſing it through water from one veſſel into another. C.

and

and form with them compounds milder than either of the conftituent parts, which are frequently difpofed to cryftallize ; 5th, they diffolve feveral earths ; and alfo 6th, fome metals ; 7th, they precipitate fubftances dif- folved in alkalis ; and 8th, they frequently attract inflammable matters ftrongly.

If, then, every one of thefe properties be found to belong to pure fixed air, properly collected and depurated, I hope its acidity will no longer be called in queftion. We fhall therefore examine all thefe circum- ftances in order.

§ iv.   *Aerated Water.*

Let the bottle ǫ r, filled with the pure elaftic fluid (§ 11.) in a place where the thermometer ftands but a little above the freezing point, be fet in a veffel of water, with its mouth depreffed, by means of weights, almoft to the bottom of the veffel, that the union may be accelerated by the preffure ; and the water will be found to rife by degrees, fo that at the end of 8, 10, 12, or more hours, according to the fize of the bottle, it will be filled with water, for the union will have compleatly deprived the fixed air of its elafticity. If after that a portion of the elaftic fluid be introduced into the bottle, the water will rife but little, or none at all. In an heat of about 5° (*h*)

(*h*) 41° of F.   B.

I   water

water will abforb a quantity of fixed air, fomewhat more than equal to itfelf in bulk; in 10° (*i*) a quantity fcarcely equal; and in temperatures ftill warmer it abforbs a quantity fo much the lefs, as the mercury ftands the higher. The quantity neceffary to faturation can hardly be determined with perfect accuracy, as the water, becoming heavier when faturated with the elaftic fluid, finks by degrees to the bottom, and leaves the fpace it before occupied to the lighter water, as would happen to any other faline folution.

This union may be effected, and that even in a few minutes, by other methods; for inftance, if by agitation we encreafe the number of points of contact.—But of this I treat more at large elfewhere (*k*), therefore have here only mentioned the moft fimple method.

The fpecific gravity of aerated water (to make ufe of a new expreffion) I found to be to that of diftilled water, nearly as 1,0015 to 1,000, the thermometer ftanding at 2° (*l*).

Water therefore, and that fubtile vapour of which we are treating, readily unite; but as the latter is very volatile, a great part of it flies off in the open air, and the quicker in proportion to the heat of the mafs; in the mean time, as it diminifhes, the remainder is retained more obftinately; fo that boiling

(*i*) 50° of F.   B.
(*k*) Vid. Analyfis Aquarum.
(*l*) 35° or 36° of F.   B.

for half an hour is neceſſary, to diſcharge the whole. Congelation ſeparates it readily and compleatly.

The air-pump, it is true, extracts bubbles from equal quantities of plain water and of aerated water, but a conſiderable difference is obſerved; for when a portion of the aerial acid is thus diſcharged, it may be eaſily diſcovered by the taſte, the water being found to have a vapid, leſs acidulous, and leſs pungent flavour.

§ v. *Fixed Air has an acid Taſte.*

As this air is in form of an elaſtic vapour, it can hardly be taſted by itſelf, at leaſt diſtinctly; but if it be united with water, which is in itſelf void of flavour, being accumulated and rendered leſs volatile by this union, it readily affects the tongue with a weak but agreeable acidity. This is the real ſpirit of the cold mineral waters, which undoubtedly occaſioned them to be called acidulous; and by means of which, together with a due proportion of ſuitable ſalts, we may perfectly imitate the Seltzer, Spa, and Pyrmont waters. Such artificial waters, I have now been uſing for eight years with ſignal advantage.

It is very remarkable, that water ſo cold as only to exceed the freezing point by a few degrees, though ſaturated with fixed air, gives out ſcarce any ſenſible flavour, but if ſet for a quarter or half an hour in $15°$ or $20°$

20° (*m*), it by degrees evolves its pungent and grateful acidity : nor is it difficult to account for this phænomenon, as it is sufficiently illuftrated by the known properties of neutral falts, the more clofely the two principles cohere, the lefs fapid is the compound; on the contrary, the loofer their connection, the more fenfible is the effect of the compound on the tongue : now in this cafe, as cold ftrengthens the union of the water with the air, and heat tends to loofen it, from thence the explanation of the phænomenon is eafily derived.

But alkaline falts not only very quickly deftroy the pungent flavour, but even make the water totally vapid, which it is not difficult to account for: if any portion of them be cauftic, that is, not faturated with fixed air, (§ vii.) their producing the fame effect, though in a flighter degree, even when they are fully faturated with air, feems to indicate that they attract fixed air more powerfully than water does, and have even the property of accumulating it, fo as to be fuperfaturated ; particularly as a few drops of the mineral acids reftore the flavour of the water, by attacking the alkaline falts, and expelling the elaftic fluid, which is therefore again abforbed by the furrounding water (*n*).

§ VI.

(*m*) 15° = 59°, and 20 = 68° of F. B.
(*n*) " This accumulation of gas in aerated alkali," obferves Mr. Morveau, " does not coincide with the
laws

§ VI.   *Fixed Air acts like a weak Acid.*

The acid nature of fixed air is discover-
able by other signs besides its taste.   If the
water in the bottle Q R be tinged with
turnsole to a perfect blue, when fixed air
sufficient to fill about the $\frac{1}{50}$ of the vessel
has passed through it, it will be manifestly
red : a saturated tincture of turnsole is ordi-

laws of the crystallization of neutral salts : perhaps
it would be better to say, that the union of the water
and the salt loosens the combination of the latter with
the fixed air.   There is at least no proof that the restora-
tion of the favour, on the addition of the acid, is not solely
owing to the fixed air, which was a constituent part of the
aerated alkali, and is thus disengaged, according to Mr.
Venel's method."   The law to which Mr. M. alludes
is not without exception.   Cream of tartar and tartarus tar-
tarisatus, calomel, and corrosive sublimate, volatile vitrio-
lic acid, and sulphur, are such obvious instances of the union
of the same principles in different proportions, as should
have made him more cautious of pronouncing on the im-
probability of a superabundant portion of fixed air com-
bining with alkali.   On this occasion it may not be im-
pertinent to remark, after an ingenious teacher of chymis-
try, that there prevails very generally an inaccurate and un-
philosophical way of conceiving and expressing such com-
binations as are mentioned above.   Two bodies can hardly
be imagined to combine in more than one certain proportion.
How, then, it will be asked, are we to explain these in-
stances?—By supposing that a compound becomes in this
respect an element, and unites with one of its constituent
parts, in order to form a new compound.   Thus cor-
rosive sublimate, which is itself formed by the union of
mercury and another salt, unites with mercury to com-
pose calomel.   In the same way we are to conceive of the
combinations of vitriolic acid and phlogiston, and   of
many others.   B.

narily

narily of a violet colour, but when fuffi-
ciently diluted lofes all the reddifh tinge,
and in that ftate therefore it is particularly
proper for this purpofe.

In like manner one part of water faturated
with fixed air, makes 50 parts of the above
tincture diftinctly red.

This change of colour, however occa-
fioned by the fixed air, foon difappears in an
open veffel, particularly if it be expofed to
heat, or the rays of the fun ; a circumftance
which indicates the volatile nature of the
acid that produces the change : a fmall por-
tion of mineral acid, it is true, feems to
yield a fugitive red, but when accurately
examined a fallacy appears, for the water
abounds with the alkaline materials with
which the turnfole juice has been prepared ;
thefe feize the mineral acid as foon as it is
added, and give out their fixed air to the
furrounding liquor, hence a rednefs is ob-
ferved, which vanifhes when this air is eva-
porated.—Let us now fuppofe that the
alkali contained in the liquor requires m
parts of mineral acid for faturation, hence
$\frac{m}{10}$ parts may be ten times added before
the faturation is compleat, and fo often a
fugitive rednefs will be produced; but after
the faturation is compleated, what is added
will either at once produce a permanent red,
or gradually change the blue to red; here
then, it is obvious that the fugitive red co-
lour

lour is not to be attributed to the mineral acid, but to the fixed air.

Syrup of violets, and such other blue vegetable juices as I have hitherto tried, are not reddened by fixed air, the tincture of turnsole is of all known tinctures most easily acted upon by acids, therefore the slightest vestiges, which cannot by any other means be discovered, are by this tincture easily detected. Besides, all acids have by no means equal strength and efficacy : distilled vinegar makes syrup of violets red, yet is not powerful enough to cause any alteration in the colour of the blue paper which is used to cover sugar-loaves ; and the colour of indigo does not yield even to the most concentrated vitriolic acid. Hence, though the aerial acid alters only tincture of turnsole, no conclusion is to be deduced from this circumstance against its acidity, all we can infer is, that it is weaker than the rest ; on the contrary, we are confirmed in the opinion that its acid properties do not depend upon an extraneous acid, for if that were the case, this extraneous acid might be so accumulated as to overcome the more permanent blue colours.

It is also observable, that aerated water, free from every other acid, scarcely makes any change in the colour of paper tinged with turnsole, although it makes the tinc-

ture

ture diftinctly red, the reafon is, partly be-
caufe a fufficient quantity of this fubtile
acid cannot come at once in contact with the
plane furface, and partly becaufe the acid is
in the former cafe at liberty to follow its
natural tendency to volatilization (*o*).

§ VII. · *Aërated vegetable Alkali.*

Let the mouth of the veffel Q_R, filled
with fixed air, be immerfed under the fur-
face of water nearly faturated with pure
alkali of tartar, and the lixivium will gra-
dually rife in the veffel; when it is at length
faturated with the elaftic fluid, let it be
poured into a proper veffel, and fet by in a
dry place for fome weeks, by that time
cryftals will be feen adhering to the fides
and bottom of the veffel; fuch of thefe
cryftals as are regular appear to be qua-
drangular prifms, the apices confifting of
two triangular planes, inclined to each
other, fomewhat like the roof of an
houfe (*p*). The faturation of the ley may be
collected from its not imbibing any more

(*o*) The aerial acid being diffufed over the paper,
prefents a much larger furface to the contact of air, and
is therefore fooner volatilized, than when, being mixed
with the water, the furface of the water is the only fur-
face of evaporation. C.

(*p*) As two of the faces are much larger than the
others, it would be as exact to define them parallelopi-
peds, of which the oppofite fides have parallel inclina-
tions. Morveau.

C

fixed

fixed air.   If the water contains too much
alkaline falt, cryftals will be produced even
in the bottle.   The fame alkali, diffolved in
water, previoufly faturated with air, pro-
duces by cryftallization   fimilar figures ;
thefe cryftals neither deliquefce in moift
air, nor efflorefce in dry, but always retain
their tranfparency : they may not impro-
perly be called aerated vegetable alkali, as
thofe falts which are faturated with vitriolic
acid are diftinguifhed by the term *vitriol-
ated*, joined to the name of that bafe with
which the acid is united.—All fubftances
faturated with fixed air I fhall call hereafter,
for brevity fake, *aerated*, thereby indicating
that they contain that acid which is always
prefent in common air (§ XXII. XXIII).

Thefe cryftals, in a moderate temperature,
require for folution four times their quan-
tity of water.   By calcination they fplit, and
lofe $\frac{52}{100}$ of their weight, but by a flow dif-
folution in acids they lofe $\frac{20}{100}$ only ; hence
it appears that in 100 parts of thefe falts,
there are 32 of water, 20 of fixed air, and
48 of pure alkali (*q*) ; hence it alfo appears
that 100 parts of pure vegetable alkali re-
quire nearly 42 of fixed air to faturate
them. Compleat calcination expels both the
fixed air and the water, whereas the acids,
if properly applied (§ VIII.), expel the for-
mer only.   However, in the prefent cafe,

(*q*) For 48 : 20 = 100 : $41\frac{2}{3}$, or 42 nearly. C.

it is fcarcely poffible to expel all the fixed air by means of fire, unlefs by an exceedingly tedious and troublefome calcination: The principle on which the corrofive quality of alkaline falts depends will be explained in fection XI.

The effervefence which thefe falts raife with acids, depends upon expulfion of the particles of fixed air by the fuperior power of the ftronger acid, and upon the recovery, at the fame inftant, of their elafticity, which had been either loft or repreffed ; they muft therefore rife to the top by their fpecific levity, and occafion a foam on the furface.

The tafte of the cryftals is indeed alkaline, but mild, and not at all acrid ; if, however, by means of calcination, or, which is better, by means of quick-lime, they be entirely deprived of fixed air, they are converted into a falt highly acrid and corrofive, which is therefore commonly called cauftic, and very readily deliquiates in the open air ; the reafon is, that it is now left to itfelf, and can fully exercife its natural acrimony, which had been repreffed and weakened by the union of fixed air. The fame phænomenon takes place with the ftrongeft acids, which being faturated with an alkaline or earthy bafis, yield mild compound falts. Thofe who attribute caufticity to phlogifton feem to have forgotten that by means of that fubftance the moft highly concentrated vitriolic

acid

acid becomes a fulphur, totally void of acri-
mony; that by means of the fame, the acids
of vitriol and nitre are fo weakened that
they may be expelled by concentrated vine-
gar; and finally, that all acids are dulcified by
fpirit of wine (r).

(r) "I am fenfible of all the force of thefe objections;
yet I will obferve, Firft, That the vitriolic acid does not
exift entire in fulphur, any more than the nitrous acid in
nitrous air, or the phofphoric acid in phofphorus; that
thefe acids do not combine with phlogifton till they have
loft their air; and that they cannot refume their acidity
till they have recovered their air, which is a conftituent
principle of that ftate.

"On the other hand, it is no lefs evident, that a fubftance
can yield thofe principles only which it contains: now
the cauftic alkalis evidently impart to the precipitates of
metallic folutions; and hence I have delivered it as my
opinion, that alkalis and calcinable earths ought to be
placed among thofe fubftances, perhaps more common
than is generally fuppofed, which cannot be difengaged
from all combination, and which do not lofe one compo-
nent part, but by the interpofition of another principle
that continues to adhere to them. (See El. de Chémie.
Dijon. vol. iii. p. 247). It will be feen in the fequel of
this differtation, that the author himfelf inclines to this
opinion, fince he admits a portion of the matter of heat in
cauftic earths and falts, of which even folution in water can-
not deprive them." Morveau.—I think that the confidera-
tions here alledged do not much invalidate the author's ob-
jections to that opinion which attributes caufticity to phlo-
gifton. Caufticity may perhaps be defined—that tendency
to combination which matter in general poffeffes, exerted
on the living and fenfible body. Thus the caufticity of acids
feems to be in proportion to their power of combination,
and that of neutral falts inverfely, as the adhefion of the
acid to its bafis. But I beg leave to refer the reader to
the article "Caufticity," in the new edition of Mr. Mac-
quer's Dictionary, where he will find the fubject difcuffed
with the ufual addrefs of that elegant and perfpicuous
writer. B.

9

The

The cauſtic alkali, when pure (by which I underſtand, deprived of its water, and particularly of its fixed air) if expoſed to the atmoſphere, attracts from thence moiſture in ſuch quantity as to be diſſolved; and hence it is called oil of tartar per deliquium. This again is gradually ſaturated with fixed air from the atmoſphere, in conſequence of which it forms cryſtalline vegetations on the ſides of the veſſel.

There are to this day perſons who inſiſt that the vegetable alkali cannot be exhibited in form of cryſtals, notwithſtanding that Profeſſor Bohnius (s), of Leipſic, ſo long ago as the end of the laſt century, had demonſtrated the contrary; but his method had been ſo long unknown, that it was lately offered to the public as a new diſcovery (t).

Although the vegetable alkali attracts fixed air very powerfully, yet it is difficult to obtain a compleat ſaturation; for in proportion as the number of cauſtic particles is diminiſhed, they are the more widely diffuſed through the fluid maſs; hence it follows that they more faintly attract, and more difficultly meet with the elaſtic fluid, a circumſtance which occurs in almoſt every ſa-

(s) See Bohnius Diſſ. Phyſico Chym. ann. 1696, pa. 381.

(t) Hence we may ſee how far Mr. Lavoiſier is miſtaken, when he aſſerts, that the original diſcovery of the cryſtallization of vegetable alkali belongs to Mr. Duhamel. B.

turation.

turation. During cryftallization fome par-
ticles ftill remaining cauftic, fully the water
of the cryftals, as is feen from the colour
of the precipitate of corrofive fublimate
which this alkali produces. Thus pure
fixed alkali precipitates a ferrugineous mer-
curial calx, but when fully faturated with
fixed air, it precipitates a white one. The
vegetable alkali, perfectly cryftallized, pre-
cipitates a whitifh calx, fullied with yellow
particles ; whereas, if thefe cryftals be pow-
dered, and expofed to the air upon bibulous
paper for fome days, they lofe all their cauf-
ticity, and precipitate fublimate in form
of a white powder : this white colour de-
pends upon fixed air adhering to the mer-
curial calx.—§ xxi. Mercury diffolved in ni-
trous acid produces different appearances,
according to the different methods of pre-
paration : thus, if the folution be effected
in the cold, and with diluted acid, a confi-
derable quantity of the phlogifton remains
adherent ; whereas, if fire be employed, a
great part of it flies off in the red vapours :
now the more the diffolved mercury is impreg-
nated with phlogifton, the paler is the pre-
cipitate made by fixed alkali ; and on the
contrary, the lefs it is impregnated, the
darker is the red colour it yields with cauf-
tic, and the more fullied the white one with
aerated alkali.

In experiments which require great ac-
curacy, I make ufe of alkali prepared from
burned

burned cream of tartar, as this is generally free from the marine acid, which, as well as the vitriolic, is in general mixed with salts elixated from vegetable ashes. All alkalis effervefce with acids, from which we may in fome meafure judge of their general nature; for the moft part they are actually faturated with fixed air, that very fubtile acid, which neverthelefs is not powerful enough to prevent them from changing blue vegetable juices green; if however, on the other hand, the acid is fuperabundant, the alkali which it faturates does not prevent it from turning tincture of turnfole red, as any one may experience in water which is impregnated with fixed air, and at the fame time holds diffolved an aerated alkali. But dry alkali of tartar feldom contains more than $\frac{23}{100}$ of fixed air, $\frac{5}{100}$ of water, $\frac{2}{100}$ of filiceous earth, and $\frac{70}{100}$ of pure alkali, of which $\frac{15}{100}$ would be in a ftate perfectly cauftic if the $\frac{23}{100}$ of fixed air were abforbed by $\frac{55}{100}$ of the pure alkali, which it is fufficient to faturate, but as it is equally diftributed through the whole, each particle wants $\frac{9}{100}$ (v) of its weight; which deficiency, for the reafons

(v) '23 of fixed air are fufficient to faturate '55 of pure fixed alkali; for (fee p. 18) 100 : 42 = 55 : 23 nearly. I am inclined to think, that into the calculation of the deficiency of weight a typographical error has crept; for this deficiency, which Mr. Bergman fays will be

recovered

reafons lately ftated, will be made up but (*u*) flowly, and with difficulty, even in the open air.

§ VIII.   *Aerated mineral Alkali.*

Fixed mineral alkali, which, when obtained from marine plants is commonly called fal fodæ, is ufually found fo much loaded with fixed air, that without any further accumulation it naturally forms cryftals with ten, or rather eight, fides, of which oppofite apices are for the moft part truncated (fig. 6.); and if it be rendered cauftic by quick-lime, it may again, like the vegetable alkali, be faturated with fixed air, § VII.

100 parts of the frefh cryftals contain of fixed air 16, water 64, and pure alkali 20, fo that 100 parts of the pure alkali require, to faturate them, 80 parts of fixed air (*w*): this is the

recovered in the open air, can, I apprehend, amount to no more than '0 '06; for, if '23 faturate 55 parts, '70 will be faturated by 29 $\frac{3}{11}$, for 55 : 23 = 70 : 29 $\frac{3}{11}$, and 0,29 — 0,23 = 0,06; and therefore I conceive the deficiency to be only $\frac{6}{100}$.   C.

(*u*) Becaufe all the particles are partly faturated, and therefore attract the faturating matter with lefs rapidity and force.   C.

(*w*) According to Mr. Lavoifier, the quintal of cryftals of foda contains 63 lb. 10 oz. of water, 15 lb. 15 oz. of elaftic fluid, and 20 lb. 7 oz. of faline matter. This analyfis coincides nearly with that of the author : but Mr.

the more extraordinary, as it is certain that
an equal weight of the vegetable alkali,
though (x) ſtronger, requires no more than
42; but ſuch is in general the nature of
ſimple ſalts, that the ſtronger they are, the
more eaſily are they ſaturated (y). The
truth of this chymical paradox may be ſhewn
in the following manner :—Let two bottles
be provided, the larger containing a given
quantity of alkaline ſalt diſſolved in water;
and let the weight of the ſolution, the bottle,
and the ſtopple, taken together = A; let the
weight of the leſſer, containing ſome ſpecies
of acid, = B; from the leſſer bottle pour
into the greater a quantity of acid, and ſtop
both ſlightly; the efferveſcence being over,
let more acid be poured in, and again ſtop
the bottles, and ſo on until the ſaturation is
compleat; then let the weight of the greater
= a, that of the leſſer = b; ſince then B — b
has been added to the greater bottle, the de-

Mr. Kirwan (Phil. Tranſ, vol. lxxii.) departs widely from
both. According to him, in 100 grs. of cryſtallized
foſſil alkali there are 35 of alkali, 20 of fixed air, and 45
of water. Mr. Kirwan thinks that the difference is owing
to the two former chemiſts having uſed ſoda recently
cryſtallized. B.

(x) By ſtronger we are to underſtand poſſeſſing the
power of diſlodging other alkalis from acids. C.

(y) This ingenious artifice affords a very eaſy method
of aſcertaining the quantity of fixed air expelled from an
alkali by means of acids, together with the quantity of
acid neceſſary to ſaturate that alkali. C.

crement of the leſſer muſt equal the incre-
ment of the larger; that is, $B - b = a - A$;
but this can never happen, unleſs the alkali be
perfectly cauſtic, otherwiſe we ſhall always
have $B - b > a - A$; and their difference
$B - b - a + A$, indicates the weight of the
fixed air expelled. The efferveſcence ſhould
be conducted gently, without heat, and in a
bottle of proper ſize, leſt ſome watry va-
pour ſhould fly off with the fixed air, and
render the concluſion erroneous.

Let the ſolution in the larger bottle be
evaporated to drynefs, and the reſiduum
be gently ignited, in order to expel the
water of cryſtallization, and the ſuperflu-
ous acid, if any there be. Let it then be
weighed, and from the increment of weight
in the given alkaline ſalt, and the weight
of the fixed air expelled, we diſcover what
quantity of acid is ſufficient to ſaturate the
fixed alkali, when freed from water and fixed
air; by this method I diſcovered that one
hundred parts of pure mineral alkali require,
to ſaturate them,

		Parts.
of vitriolic acid	- -	177
—— nitrous	- - -	$135\frac{1}{2}$
—— marine	- - -	125
—— atmoſphæric	- -	80

and that one hundred parts of pure vegetable
alkali require, for ſaturation,

				Parts.
of vitriolic acid	-	-	-	$78\frac{1}{2}$
— nitrous	-	-	-	64
— marine	-	-	-	$51\frac{1}{2}$
— atmofphæric	-	-	-	42

The quantities of fixed air before affigned to the mineral and vegetable alkalis agree precifely with this table.

What has been already affirmed of alkalis holds good of acids, deprived of their fuperfluous water : thus 100 parts of vitriolic acid require

			Parts.
of pure vegetable alkali	-	-	$127\frac{1}{2}$
— mineral	-	-	$56\frac{1}{2}$
— volatile	-	-	42

Cryftallized mineral alkali, in a dry air, lofes its water, together with its tranfparency, and breaks down into a powder; it diffolves in a moderate heat in about twice its weight of water : befides, many properties of the vegetable alkali (mentioned in § VII.) belong to the mineral. The reafon why it cannot, like the vegetable alkali, precipitate corrofive fublimate in a white powder, fhall be explained in § XXI.

§ IX.   *Aerated volatile Alkali.*

To obtain the volatile alkali regularly cryftallized, I chofe that which, being ob-
                                        tained

tained from fal ammoniac by means of chalk, and a due degree of heat, is faturated with fixed air; I then faturated water with it in a clofed bottle, and finally expofed it gradually to intenfe cold; notwithftanding which, I could not obtain figures perfectly regular—they feemed indeed fomewhat oc-taedral, with four truncated angles—fee fig. 7, which exhibits the upper furface.

The cauftic volatile alkali, prepared with quick-lime, attracts water very vehemently; it is therefore always fluid, very penetrating, and exceeding volatile: by the method de-fcribed § VII. it is eafily rendered mild, and is to a certain degree fixed, and difpofed to cryftallize.

This alkali is weaker than the fixed, and therefore, according to the rule above men-tioned, it fhould require a greater quantity of fixed air to faturate it; and experiments confirm the truth of this, for 100 parts of this alkali, when pure, take up near 105 of the aerial acid, and hence alfo it occafions a more violent effervefcence with acids—100 parts of concrete volatile alkali ufually contain 12 of water, 45 of fixed air, and 43 of pure alkali.

§ X.   *Aerated Terra Ponderofa.*

That bafis which, faturated with vitriolic acid, forms the fpathum ponderofum (the marmor metallicum of Cronftedt, § XVII. XIX.)

xix.) bears a ftrong refemblance to calca-
reous earth, but as it differs in many parti-
culars, it is neceffary to make a diftinction,
until new experiments throw more light on
the fubject. The effervefcence which this
fuftance occafions with acids manifeftly in-
dicates the prefence of fixed air : that I
might be more intimately acquainted with
this combination, I expelled the fixed air
by burning ; poured water on the refiduum,
fhook it, and then filtered it—after it had
ftood a few hours in the open air, I faw the
furface flowly covered with a cream, and all
that was diffolved in the water feparated by
degrees, in the very fame manner as happens
with lime-water. This pellicle effervefces
with acids, hence we may certainly conclude
that the principle which had been expelled
by the fire is now reftored: by a fufficient
degree of heat 0,35 of the weight are loft,
and the bottom of the veffel acquires a
bluifh colour, but by flow folution in acids
not more than 0,07 are loft; hence it ap-
pears, that one hundred parts contain 7 of
fixed air, 28 of water, and 65 of pure terra
ponderofa. Water can take up about $\frac{1}{900}$ of
its own weight of this earth in its pure
ftate, and when faturated with it precipi-
tates corrofive fublimate in the form of a
yellow powder: it blackens merc. dulcis,
and changes the colour of vegetable ex-
tracts, in the fame manner as lime-water
does; it is alfo to be obferved, that this
earth

earth acquires folubility in water more eafily, if it be feparated from the nitrous acid by fire, than it does by being calcined alone. Although this earth, faturated with fixed air, will not enter into an union with common water, yet it diffolves in water impregnated with that fubtile menftruum; for water in that ftate takes up $\frac{1}{1350}$ of its weight, and even much more, if the earth be reduced to a powder as fine as that of a precipitate: this folution changes the red colour of paper tinged with Brazil wood, to a blue; it heightens the colour of paper flightly tinged with turnfole; but when the menftruum is fuperabundant, it reddens the tincture; it fcarcely changes paper ftained yellow by turmeric root: in the open air, the fuperabundant menftruum gradually flying off, a cruft is formed of the fame kind as that occafioned in the former folution, by the fame menftruum being attracted to faturation from the atmofphere (z).

§ XI.

(z) "Ponderous earth," fays M. Morveau, "is hitherto but imperfectly known to the French chemifts. Mr. Monnet alone has paid attention to it: he found that the ponderous fpar is far lefs fufible than gypfum; that the earthy bafis forms, with the mineral acids, falts very different from thofe produced by the combination of the fame acids with calcareous earth."— He differs widely from Sir T. Bergman on a point of fome confequence, for he contends for the exiftence of fulphur compleatly formed in the ponderous fpar; he afferts that he has obtained liver of fulphur, by treating it alone with alkali in

clof

§ XI.

Experiments fhow that the tranfparent calcareous fpar, when expofed to a fufficient degree of heat, lofes 0,45 of its weight, together with the property of effervefcing with acids, at the fame time that it acquires acrimony and folubility in water; the caufe of this change has been of late the fource of much contention, but if I am not totally deceived this difpute may now be decided, both analytically and fynthetically. Thus, if, by the fecond method (§ 11.) we collect the volatile fluid expelled in burning, it upon examination is found to be no other than fixed air, and is equal in weight to about 0,34 of the crude mafs; the fame lofs is fuftained by flow folution in acids, the remainder, which is 0,45 — 0,34 = 0,11, confifts of water neceffary to cryftallization, which may alfo be feparated by a proper diftillation. The prodigious velocity with which the fixed air flies off occafions it to

clofe veffels; he confequently confiders it as a true earthy cryftallizable liver of fulphur. On communicating to Sir T. Bergman this experiment and deduction of Mr. Monnet, that chemift returned for anfwer, that he could not but allow that the ponderous fpar may fometimes contain fulphur, but he confiders the fulphur as an extraneous fubftance; in confirmation of which he obferves, that it is only prefent by accident, and that the ponderous fpar may be re-produced by fynthefis, poffeffed of all its effential properties; viz. by combining vitriolic acid and ponderous earth. This anfwer feems decifive. B.

7

carry off a fmall portion of watery vapour, infomuch that the whole of the water cannot be collected in this way, unlefs by means of an apparatus adapted to that purpofe ; this analyfis is fully confirmed by fynthefis : ——— Let the bottle Q R be filled with clear lime-water, and let a fufficient quantity of fixed air be introduced through a very flender tube, fo that it may be immediately abforbed ; by degrees the liquor grows turbid, and flowly depofits a powder, which effervefces with acids, is not foluble in water, and is void of acrimony, that is, poffeffes all the properties of lime-ftone, which properties, together with the above-mentioned part of its weight, it lofes again, upon expofure to fire.——It is with juftice, therefore, that we confider calcareous matter as a neutral falt, of which cryftals are of an obliquely parallelopiped figure, which is called fpathaceous—of which the compofition is fuch, that 100 parts contain about 34 of atmofphæric acid, 11 of water, and 55 of pure calcareous matter, quite freed from air and water.

Pure lime can be wholly diffolved in water, but we muft take particular notice that not only a confiderable quantity of water is required (as it fcarce takes up $\frac{1}{700}$ of its own weight) but the water muft alfo be compleatly purged of fixed air, by violent boiling for half an hour, for if the fmalleft portion of fixed air remain, it faturates more than its own weight of pure lime, which

thereby

thereby becoming indiffoluble falls to the bottom. If therefore any of the lime remains undiffolved, it fhews either, 1ft, a mixture of heterogeneous matters; 2d, that the lime is not well burned; 3d, that the water is unfit for the purpofe; or 4th, that it is ufed in too fmall a quantity. The 2d and 3d impediments are eafily difcovered, by the effervefcence of the refiduum with acids; nor will the detection of the other two give much trouble to an expert chymift.

Since then pure lime and fixed air feparately are with eafe diffolved in water, it may be afked, Why fhould not the compound be alfo foluble ?—We have long fince obferved, that the acceffion of fixed air diminifhes the folubility of alkaline falts and terra ponderofa; it fhall now be demonftrated, that other acids produce the fame effect. Pure vegetable alkali is very deliquefcent, and vitriolic acid retains water with fuch force, that it cannot be exhibited in a feparate ftate by any means yet known; yet if thefe two be combined to the point of faturation, a neutral falt is produced, one part of which, in a moderate heat, requires 16 of water to diffolve it. This is one notable example, and upon enquiry hundreds more will occur.

We know that vitriolated vegetable alkali, gypfum, and other falts difficultly foluble, are more eafily taken up by water, if it be acuated by an acid. May not aerated

D lime,

lime, therefore, be acted upon in the fame way by fuperabundant fixed air ? at leaſt, if we admit fixed air to be an acid, we ſhould expect ſuch an effect, and upon experiment this appears to be the fact. Let a fmall portion of lime-water be dropped into wa- ter impregnated with fixed air, ſlight clouds are immediately formed, occaſioned by the faturation of the lime by the fixed air ; theſe clouds however diſappear upon gently ſhak- ing the veſſel, the lime being again diſ- folved by the fuperabundant fixed air. Put into a bottle, filled with aerated water, tranſ- parent calcareous ſpar reduced to an exceed- ingly fine powder ; let this bottle be kept well corked in a cool place for fome days, and a part of the ſpar will be found diſſolved ; this folution, filtered through paper, by its fuperabundant fixed air reddens the tinc- ture of turnſole (lime-water heightens its blue colour) ; it fcarcely ſtains blue a paper tinged red by Braſil wood (lime-water oc- caſions a deep blue colour) ; it does not change the yellow colour of turmeric (lime- water makes it ferruginous) ; in the open air it forms a cream upon the furface, as it is there the fuperabundant menſtruum firſt flies off (whereas the cream of lime is to be afcribed to the attraction of fixed air from the atmofphere) ; finally, by gentle evapora- tion it depoſits an aerated lime, of about $\frac{1}{1500}$ its own weight, which to the eye, aſſiſted by a

<div align="right">glaſs,</div>

glafs, frequently exhibits the fpathaceous figure (*a*).

It

(*a*) M. de Sauffure has a curious obfervation relative to this fubject :—he was analyfing a fulphureous fpring in the neighbourhood of Geneva. " A lucky accident," fays he, " prefented me with a new and curious obfervation upon the calcareous earth held in folution by this water. I had been trying to feparate by the filter the fulphur, which in the courfe of a few hours precipitates fpontaneoufly, and renders the water turbid. I afterwards put that which had paffed through the filter, and was rendered limpid, into a large bottle which had a ground ftopple. It had remained quite full for a year in the fame place of my ftudy, when I wanted it for fome other purpofe ; but before I threw away the water, I was defirous of feeing whether it had undergone any change. At the bottom I perceived a fpecies of conferva of a green colour. In order to infpect this plant more minutely, I half emptied the bottle, and then fhook it, in order to difengage the plant ; which, notwithftanding, continued firmly attached to the bottle, but in the mean time I perceived a great number of white, fhining, oblong, and narrow laminæ, floating in the water, which drew all my attention. Having collected them carefully, I found that the longeft were about half an inch in length, and $\frac{1}{24}$ in breadth, and of the thicknefs of a fheet of paper. The microfcope fhewed them to be formed by the junction of feveral tranfparent cryftals, of which the prominent fummits had the fhape of a triangular pyramid, and exactly refembled the fpar commonly called *pig's tooth* fpar. I further found that thefe cryftals were entirely.foluble with effervefcence in the nitrous acid, and that with the vitriolic acid they compofed felenite ; fo that I could not doubt that they were real cryftals of calcareous fpar.

" By fcraping the bottom of the bottle a concretion like tartar was detached, which I found to be compofed of fmall cryftals of the fame fhape and nature as thofe juft defcribed, but the laminæ formed by their junction, inftead of being ftraight, were varioufly reticulated.

" It was known before, that earthy cryftals might be

obtained

. It may perhaps be faid, that it is in the fire the lime acquires its faline properties; many are ftill of that opinion; and it is certain that this thefis may be fo explained as not to contradict the fynthefis and analyfis above defcribed: for, fay they, the whole difference between crude lime and quick lime does not depend upon the prefence or abfence of fixed air and the water of cryftallization, for the lime receives in the fire the matter of heat (*b*) (the fixed air and water being previoufly expelled) by which the efficacy of its attraction is in fome degree diminifhed; by this new union it is that it becomes foluble: but the caufticity is to be explained entirely upon the lofs fuftained by means of the fire, as we fhall foon fee. Terra ponderofa, and all the alkaline falts, in the fame way receive the matter of

obtained by the evaporation of water, holding chalk in diffolution by means of fixed air. This interefting difcovery belongs to Mr. Achard of Berlin; but I believe there is no inftance on record of fuch cryftals formed in the water without the aid of evaporation. This fact, however trivial in appearance, feems to me of great importance with refpect to the theory of the formation of the mountains in the midft of the waters." B.

(*b*) Numberlefs phænomena, which we cannot here confider, evince beyond a doubt that heat is the effect of a certain material fubftance.—It is fufficient here to obferve, that the fubtile matter of heat occurs in two diftinct ftates; either it is at liberty, in which ftate it pervades all bodies, fo that all attain the fame temperature, or it is fixed by attraction, and does not exhibit fenfible heat, until fet free by fome more powerful attraction.

heat;

heat; and hence we underftand how, by a double elective attraction, lime, diffolved in acids and precipitated by cauftic fixed alkali, is entirely fimilar to lime prepared by fire, and flacked in water. The heat which new-burnt lime generates with water indicates no more than a loofe adherence of the matter of heat, which is repreffed, and prevented from producing fenfible heat, nearly in the fame way as the properties of acids are rendered latent by their union with alkalis: but upon the accefs of a fufficient quantity of water, the matter of heat is immediately feparated by means of a ftronger attraction, and, being thus fet at liberty, communicates fenfible heat to the fuperabundant water. If the lime be gradually flacked by the moifture of the furrounding atmofphere, no fenfible heat is generated: but we muft take particular notice, that lime which generates heat with water is fcarcely deprived of all its fixed air; for the intimate nucleus, at leaft, is found ftill to effervefce with acids; and if this refiduum be expelled, the lime becomes as it were dead and inert, and, although ftill foluble in water, it neither fplits in flacking, nor occafions any heat. It may be here afked, How it comes, that by the intenfity of the fire the faculty of heating is loft, while the folubility remains?—This is perhaps owing to the vehemence of the fire, to which the greateft part of the matter of heat, being

very

very volatile, is obliged to yield. The workmen reject lime which is too much burned, as being ufelefs, as it does not fplit into powder, which is neceffary for mixing it ; whereas lime lefs burned, in the inftant of flacking, breaks into a powder : for in the latter cafe, the greater part of the fixed air being expelled by the burning, the bulk of the lime is indeed much contracted, but it yet remains of a very fpungy texture : —water poured upon this readily penetrates it, fets at liberty the hidden particles of heat ; and being by that heat refolved into vapour, breaks the whole mafs to pieces, and reduces it to a fine powder. Lime, as well as terra ponderofa, and magnefia, and alfo the alkaline falts, when cauftic, even after extinction in water, produce heat on mixture with acids, the refiduum of the matter of heat, which water alone was unable to expel, being fet at liberty ; but thefe fubftances, being cryftallized, produce no heat with acids (c).

All

(c) " When chalk, cryftallized vegetable alkali, &c. are diffolved in concentrated acids, a very confiderable heat is produced, a phænomenon which naturally ought to appear ; becaufe, without attending to the fixed fire, collifion always produces heat. As the fum of the fynchronous collifions is far lefs confiderable, when diluted acids are employed, the cold occafioned by evaporation compenfates, or even furpaffes, the heat produced, as I have proved in the 2d vol. of the Dijon Mem." Morveau.——Having never feen the relation of thefe experiments to which M. de M. alludes, and on which his

opinion

All the circumstances mentioned in this section, as well as the preceding (§ VII.—x.) being confidered, or, for fuller conviction, being often put to the proof, I doubt very much whether caufticity can with propriety be derived from any adventitious matter, especially as it may be explained fimply and plainly by elective attraction, a power to which all bodies on this globe are found to be obedient; for the purer any matter, the more powerful is its effort towards an union with other fubftances; fo that in this ftate, acting with undiminifhed force, it feizes with the greater violence thofe fubftances with which it has an affinity, and, if powerful enough, diffolves their former connection; hence it exerts a violent acrimony, but as it is gradually faturated, its force becomes weaker, until a full faturation taking place, all this corrofive faculty vanifhes, and can no other way be reftored, than by expelling the

opinion is founded, I cannot well judge concerning its validity; I am, however, fomewhat inclined to fufpect it: for if the heat produced by the collifions be compenfated or furpaffed by evaporation, when a weak acid is ufed, an effect not very diffimilar ought to follow, when a more concentrated one is ufed; for in this cafe, the collifions being more numerous and inftantaneous, the evaporation, and confequently the quantity of fire carried off in vapour, fhould likewife be more confiderable: befides, it is fcarce credible that the cold produced in fome folutions can be owing to evaporation, it is fo intenfe. I am therefore much more inclined to attribute, with Dr. Black, the production of cold to the converfion of a quantity of abfolute, into latent heat. B.

faturating

faturating matter. The matter of heat ra-
ther repreffes than quickens caufticity; it
however repreffes it but imperfectly; and
hence the prefence of caufticity always indi-
cates a powerful attractive effort, together
with the abfence of the fubftances for which
the cauftic body poffeffes a very violent at-
traction (d).

It

(d) " The more chymiftry is improved, the more nu-
merous and cogent will be the proofs of this theory. But
I will here add a few remarks to thofe upon § VII.—1, as
quick lime cannot be deprived of all the fixed matter of
heat, it cannot be affirmed that its properties, in this ftate
of combination, belong exclufively to one of its confti-
tuent parts; 2, it is certain, not only that compounds,
quatenus compounds, have their peculiar affinities; but it
is befides certain that, in fome cafes, thefe affinities can
be exerted only on compounds. Mr. Bucquet has ob-
ferved, that quick lime does not flack in fixed air, but it
may be inftantly flacked in aerated water; which proves,
that water is a neceffary intermede to the union of the
gas; 3, the inertnefs of burnt lime feems very diffi-
cult to be explained. Sir T. Bergman's conjecture ap-
pears repugnant to the general law; according to which,
every body that cools in any fluid always retains a por-
tion of that fluid, as a cryftallizing body always retains
part of the liquor in which it was diffolved. I fhould
therefore rather fuppofe that the violence of the heat muft
have deftroyed part of thofe principles which this earth
derives from organized bodies, and which conftitute it
calcareous earth." Morveau.——I am ready to allow that
the author's conjecture is not very probable; but the annota-
tor's feems alfo very vague and unfatisfactory, more efpeci-
ally if we confider that there ftill fubfift doubts concerning
the origin of calcareous bodies. — M. Buffon, and there-
fore, of courfe, the whole herd of French chemifts and
naturalifts, contend, that they are the product of the accu-
mulated fpoils of marine fubftances. Mr. Pallas and

M.

It has already been faid, that the moft fimple figure of aerated lime is that which is called fpathaceous: I have, I imagine, elfewhere fufficiently explained how from this are formed the granatic, bafaltic, and other figures (*e*).

§ XII. *Of aerated Magnefia.*

The magnefia which is found in the fhops, although vulgarly called an earth, is yet of a faline nature; for in a moderate heat diftilled water is capable of diffolving $\frac{1}{830}$ of its own weight; and analyfis con-

M. Sauffure too, incline to this opinion: but a diftinguifhed naturalift has of late combated this opinion, with arguments of great apparent weight. " Calcareous matters," fays M. de Luc, " cannot have derived their characteriftic properties from the fpoils of marine animals; 1, becaufe thofe fpoils muft neceffarily have been lefs abundant during the moft remote times, and it was during thofe remote times, that the moft confiderable accumulations of calcareous matter were made; 2, becaufe thofe great accumulations, fuch as the calcareous Alps, contain a far fmaller number of marine fubftances than many accumulations of a different nature; 3, becaufe calcareous matters have been found among *primordial* fubftances, that is to fay, fuch as are prior to all thofe in which the probable effect of known caufes can be recognized." So far M. de Luc.—With refpect to the change produced on lime by calcination, carried too far, is it abfurd to fuppofe that it may arife from fuch an alteration as bears fome analogy to an incipient vitrification? But in queftions of fo great obfcurity, there are no bounds to the licentioufnefs of conjecture. B.

(*e*) Treatife on the Formation of Cryftals.

firms

firms this opinion, as it fhews that the primary principles of magnefia, are a peculiar kind of earth faturated with fixed air and water. Common magnefia, by proper calcination, lofes 0,55 of its weight, but a vehement and long-continued fire diffipates fomewhat even of the earthy bafis; by flow effervefcence in acids, only 0,25 are loft; hence it appears, that 100 parts of magnefia contain about 25 of fixed air, 30 of water, and 45 of pure magnefia, which appears to be a true earth; at leaft, although blended with the matter of heat, I have never yet been able to diffolve it in water. Magnefia fully faturated with air, and cryftallized, in 100 weight contains 30lb. of fixed air: the vapour which is expelled either by fire, or acids collected by the methods defcribed § 11. and examined, exhibits all the marks of fixed air; in this inftance the collection of the elaftic vapour expelled by the fire in the bottle (§ 11.) is attended with the lefs trouble, as it is more loofely connected with the magnefia, whereas it adheres very ftrongly to lime, fo as to require a more violent fire; hence, when lime is ufed, it becomes neceffary to provide a glafs of proper thicknefs, and very difficult of fufion, and to furround it with powder of burnt bones, or gypfum, to prevent it from being fufed. In general too, we may remark, that the greater the diameter of the body of the retort, the more difficult will it be to make

the

the neceffary heat penetrate to the centre; befides, it will be neceffary to encreafe the force of the fire continually, for if it at any time is remitted, the tube c f e draws up the water; this inconvenience is fomewhat leffened by continuing the extremity g of the tube nearly to the bottom h of the veffel:—I have fitted up common tobacco-pipes for this purpofe, and found them very convenient.

The greateft part of the magnefia which is found in the fhops is prepared by precipi-tation from Epfom falt; but if the alkali made ufe of be well impregnated with air, the precipitation will be fmall, particularly in a large quantity of water; for the fixed air, expelled from the alkali by the vitriolic acid, attacks the deferted magnefia, and dif-folves it; but by a boiling heat the fuper-abundant volatile menftruum is diffipated, the magnefia is brought to the point of fa-turation, and almoft all precipitates.

Water well faturated with fixed air dif-folves, in a moderate heat, about $\frac{1}{300}$ of its own weight of common magnefia, and double that quantity, if it be as fine as a precipitate. This folution turns the tinc-ture of turnfole red, but heightens that of paper flightly tinged by it; makes paper tinged with fernambucum blue, but fcarcely obfcures the yellow colour of turmeric (for reafons affigned below, I do not make ufe of fyrup of violets); upon the addition

of

of an acid, innumerable bubbles appear: pure fixed alkali precipitates an earth which does not effervefce with acids, provided the alkali be ufed in quantity fufficient to take up all the fixed air, if in lefs proportion an effervefcence takes place. If the alkali ufed be fully faturated with fixed air, it has no effect on the folution, unlefs the water be infufficient to hold both diffolved, in which cafe the magnefia feparates. Pure volatile alkali alfo throws down a precipitate, but an effervefcing one, as it can attract only the fuperabundant fixed air; with folution of corrofive fublimate it grows milky, and gradually depofits a fmall quantity of white powder; afterwards thin blackifh cryftals concrete, compofed of mercurius dulcis, and a calx of mercury partially aerated. The fmalleft drop of a folution of mercury, made by heat in nitrous acid, occafions a copious yellowifh brown precipitate: but the fame folution, made without heat, yields a white powder, which after fome days grows greyifh, as in this cafe the metal has loft but a little of its phlogifton. Thefe changes may perhaps be afcribed to a mixture of alkali adhering to the precipitate of corrofive fublimate, and which cannot be wafhed away: but this fufpicion foon vanifhes, for magnefia has the fame effect, whether it be precipitated by fixed or volatile alkali, and befides, precipitates occafioned by volatile alkali, difap-

pear

pear in a few minutes, while thofe which depend on magnefia are permanent.

§ XIII. *Aerated Clay.*

Fixed air fcarcely ever attacks pure clay, that is, the earth of alum dry and compact, yet the precipitation of alum by aerated alkali fhews that it does not altogether re-fufe to unite with it, when fufficiently fine and comminuted; for the liquor, well fil-trated, although clear, after ftanding a few days in the open air, and in a degree of heat fufficient to expel the fixed air, grows tur-bid, and by degrees depofits a fmall portion of earth, which had been fufpended by the volatile menftruum. Common clay, ex-pofed to violent heat, gives out a quantity of fixed air feveral times greater than itfelf in bulk, mixed with a fmall portion of inflam-mable air, which comes off by the firft action of the fire.

We have already compared (§ VIII.) the alkaline falts, with refpect to the quan-tity which will faturate equal parts of the fame acid; we fhall here add numbers pro-portioned to the weights of the different earths diffolved by the fame meafure of ma-rine acid :

pure

pure clay   -   1, o
pure magnefia   -   2, 2   aerated   5,7
pure lime   -   3, 5   aerated   6,o
pure terra ponderofa 8, 7   aerated 1 3,5

Here follow the weights of abforbent
earths, which can unite with 100 parts of
aerial acid :

pure magnefia   -   150   (§ xii.)
pure lime   -   -   162   (§ xi.)
pure terra ponderofa   926   (§ x.)

Therefore the law demonftrated (§ viii.) of
alkaline falts alfo holds good of earths.

Silecious earth eludes the force of fixed
air, and all the other acids, except that of
the mineral fluor.   The more fimple earths,
therefore, being now confidered with relation
to the aerial acid, we go on to the metals.

§ xiv.

As far as I know, fixed air alone, in its
elaftic ftate, does not diffolve nor even cor-
rode any metal, unlefs perhaps during cal-
cination ; but when united with water it at-
tacks fome of them.   Let iron-filings be
put into aerated water, let the bottle (well
ftopped and inverted) be fet in a cold place,
and after twenty-four hours a portion of
the iron will be found diffolved, fo that the
water

water will ftrike a purple colour with (ƒ)
tincture of galls, make fyrup of violets
green, and form, with phlogifticated alkali,
Pruffian blue. If this folution be expofed
to the open air, the furface which firft lofes
the menftruum exhibits a party-coloured
pellicle, compofed of particles of iron, re-
duced to fuch tenuity as to reflect different
colours ; by degrees all the iron is feparated
in form of a fubtile ochre, which amounts
to nearly $\frac{1}{10500}$ part of the weight of the
water, and when frefh retains fo much of
the principle of inflammability as to obey
the magnet, and be foluble in the mineral
acids: — Cauftic alkali, whether fixed or
volatile, feparates this metal from the water,
but when fully aerated has no effect.

Water, impregnated with the fixed air
expelled by heat from magnefia or calcareous
fpar, or that collected from fermenting fub-
ftances, fcarcely takes up any calcined iron,
except at the inftant of its precipitation,
when it is fcarcely obedient to the magnet;
but if the ordinary method of effervefcence
without wafhing be employed, the water is
always contaminated with vitriolic acid;
moft commonly, indeed, fo fparingly as not
to change the colour of fyrup of violets
diftinctly, though it reddens paper tinged

(ƒ) I make ufe of fpirituous tincture, as it is more ef-
ficacious than the watery tincture, and can be kept un-
corrupted.

with

with turnfole, which water loaded with
pure fixed air is never able to do (§ vi.);
and befides, a drop or two of folution of
terra ponderofa in the nitrous or marine
acids, acts as a very certain teft, and by a
flow congrumation detects even the fmalleft
traces of vitriolic acid, which cannot fo
well be difcovered by any other means yet
known. I am the more certain that this
mixture is moft commonly the caufe of the
folution of iron calx, as I have often, by
adding it, produced this effect, which water
fully aerated was unequal to ;—during cal-
cination, indeed, the iron feems to unite
with fixed air, but water can fcarcely take
up that compound.   ,

§ xv. *Aerated Zinc.*

Aerated water will diffolve zinc very co-
pioufly, either in its metallic ftate, or cal-
cined by the procefs defcribed in the fore-
going fection. The metallic folution, ex-
pofed to the open air, foon fhews its furface,
covered with party-coloured atoms of zinc ;
whereas that which contains the calx ap-
pears more obfcure, with lefs variety, and
lefs refplendency of colour. The pellicles
which earthy and metallic bodies diffolved
by aerated water yield, on expofure to open
air, nearly agree with thofe which appear
upon evaporating folutions of other falts, as
in both inftances the neceffary quantity of
menftruum

menftruum becomes firft deficient on the furface.

Alkali, when perfectly cauftic, as alfo tincture of galls, and phlogifticated alkali, precipitate the metal of a yellowifh afh colour. Alkalis fully aerated produce no effect; but as thofe in common ufe poffefs fome degree of caufticity (§ vii.), they are not entirely inactive.

§ xvi. *Aerated Manganefe.*

That femimetal which is found in the magnefia nigra, or glafs-makers magnefia, and which feems to be diftinct from all the other femimetals hitherto known, I call manganefe. Aerated water takes up the black calx of this metal, but far more copioufly the regulus, in fuch a manner however that it alfo takes up the iron which is mixed with it. If the regulus be employed, the folution diffufes a particular fmell, not unlike that which proceeds from burned fat; but the precipitate and pellicles are the fame as above defcribed, except as to colour, which is generally influenced by the prefence of iron: moreover, phlogifticated alkali precipitates pure manganefe of a yellowifh white, and tincture of galls produces nearly the fame colour.

E § XVII.

§ XVII. *Union of fixed Air with other Metals attempted.*

The metals above-mentioned are eafily diffolved by aerated water, whereas fome of the others cannot unite with it, except when divided, as in the very inftant of precipitation ; and moft of them cannot, even by this artifice, be brought to do fo. The following metals I put into aerated water, and kept them in bottles well ftopped and inverted, in a cool place, for eight days, at the end of which time I examined them : viz. gold leaf, aurum fulminans, platina, filver leaf, mercury, Æthiops mineral prepared without heat, turbeth mineral, granulated lead, calcined copper, granulated copper minium, ceruffe, leaf tin, calcined tin ; as alfo the femimetals bifmuth, nickle, arfenic, cobalt, and antimony, both reguline and calcined ;—the water of each bottle was filtered through paper into a feparate veffel, and was found ftill to retain all its fixed air, for it reddened the tincture of turnfole, as before; but moft of them fhewed no figns of folution having taken place. The bifmuth indeed, the cobalt, and the antimony, both reguline and calcined, as alfo the regulus of arfenic, in the open air, fhewed exceeding thin party-coloured pellicles, which could hardly be obferved ; but on the addition of cauftic alkali, they

exhibited

exhibited flight clouds, and produced, with tincture of galls, a violet-coloured precipitate, so that I could scarcely doubt but these phænomena were owing in a great measure to an admixture of iron : yet pure cobalt, as well as nickle, gave some tokens of being diffolved, but these tokens I hold to be ftill ambiguous.

I tried gold leaf in another way, but in vain ; namely, I put into diftilled water, along with the leaf, either the calcareous fpar, or aerated alkali, then by degrees I poured in vitriolic acid, fo as not to produce a full faturation, yet after fome days I found no folution had taken place ; once indeed, when I ufed chalk and common water, I faw fome veftiges of a folution, but upon examining more accurately, I found a little marine acid in the chalk, and difcovered lime diffolved in nitrous acid in the water, from whence a fmall portion of aqua regia had been generated. The vitriolic acid itfelf is frequently found to contain a portion of nitrous acid, which is ufually employed to difcharge its brown colour :—The moft extreme caution is neceffary to avoid being deceived by adventitious circumftances.

But, becaufe the metals were tried in this way in vain, we are not to affirm that they cannot be united with fixed air, for perhaps it might be done, if they were minutely divided by precipitation ; I examined this fuppofition in the following manner :—To

E 2 the

the folution of a metal in its proper folvent, diluted with a fufficient quantity of diftilled water, I added, by degrees, either aerated vegetable alkali, magnefia, or calcareous fpar; the faturation being compleated, I kept the bottles clofed and inverted, in a cold place for fome days, and then examined the water after filtration : I avoid making ufe of chalk, which is often mixed with marine acid, and therefore in certain cafes might occafion confufion ; with crude lime, the faturation is obtained very flowly, efpecially if the menftruum be vitriolic acid, partly becaufe the furface, affuming a gypfeous nature, defends the internal particles, partly becaufe the laft portion of the acid can only meet with the chalk at the bottom of the veffel, unlefs the liquor be frequently ftirred ; while, on the contrary, the magnefia, and efpecially the alkali, by their folubility, are fpontaneoufly difperfed through the whole mafs : magnefia however is beft, inafmuch as, though it diffolves fpontaneoufly, yet the folution goes on fo flowly, that the water has time to take up the greateft part of the fixed air, as it is expelled ; whereas, when the effervefcence is violent, a great number of bubbles rife to the furface, and fly off.

By this method, befides thofe metals formerly enumerated, which may be directly diffolved in aerated water, a fmall quantity of gold appears to be taken up, but that in fo ambiguous a manner, that, upon

examination,

examination, I am ftill undecided. Gold is precipitated from aqua regia very flowly, by magnefia and by lime, and but imperfectly by alkalis, as a part of the precipitate is re-diffolved by the precipitant ; fo that the liquor can fcarcely be divefted of its yellow colour. The folution of gold, which with tin depofits a purple powder, does not hold the gold diffolved by the fixed air alone; for, to occafion a precipitation, it is neceffary that there fhould be prefent a menftruum fuch as may be able to take up the tin—which aerial acid cannot do.

I fubjected platina, filver, mercury, lead, and the other metals and femimetals, to fimilar experiments ; but the event was the fame, and I found no certain tokens of folution. That ceruffe fhould refufe folution by the medium of fixed air, furprized me, efpecially as it is itfelf nothing more than an aerated calx of lead, and therefore diffolves in acids, with effervefcence, and the vapour which is expelled poffeffes all the properties of fixed air. In this experiment I employed ceruffe perfectly free from chalk. —In like manner filver, mercury, copper, tin, bifmuth, nickle, and the other metallic fubftances, diffolved in acids, and preci-pitated by aerated alkalis, take up the fixed air, but yet cannot by its means be diffolved, except that when the acid is fuperabundant, before the precipitation, a fmall portion of copper is taken up ;—a compleat precipita-

E 3.

tion is with difficulty obtained by lime and magnesia, though used in large quantities. The metallic salts always redden paper tinged with turnsole, a property which it is extremely difficult to repress by means of the above-mentioned earths.

§ XVIII. *Inflammable Matters greedily attract fixed Air.*

The common acids frequently attack inflammable bodies with peculiar avidity, as is well known; although the union of an acid with pure phlogiston (which is commonly called sulphur) takes place but in few of them—fixed air also possesses this same property.—If the bottle Q R, filled with fixed air, be plunged with its mouth under spirit of wine, the spirit will be found to absorb, in a temperature of 10°, double its own bulk of fixed air.—Let the same experiment be tried with olive oil, and it will be found that it will absorb an equal, nay sometimes a greater, bulk than its own; so that a stratum of oil floating upon water is of little use, as it scarcely, if at all, retards the absorption of fixed air. Oil of turpentine absorbs nearly twice its own bulk, and that in the beginning with such avidity, that in the first half hour about a fourth part of the fixed air disappears. Ether does not diminish fixed air, but expands it nearly to a double volume; however, if this vapour be again

passed

paſſed through water, it reaſſumes its original quantity and quality, ſo that the extraneous mixture preſent in this caſe cannot effect a permanent change.

Fixed air is not without difficulty combined with pure phlogiſton (yet they appear united in charcoal) (g); and perhaps this union may alſo be effected by electric ſparks drawn quickly through it, by which means the fixed air is ſo loaded with phlogiſton as to reject an union with water: if the fixed air which olive oil holds united with it be again expelled by fire, and received in a veſſel, it is found either to a certain degree changed, or mixed with heterogeneous matters; for it can now ſuſtain flame, and is almoſt inſoluble in water (h).

§ XIX.

(g) "As charcoal neceſſarily contains a portion of earth, it ought, I think, to be conſidered as an hepar, or ſalt of three ingredients; beſides, neither the phlogiſton nor the fixed air are quite pure; the former is in the oily ſtate, and it is probable that the latter is only a conſtituent part of a mere compound acid." Morveau.—This (I fear conjectural) analyſis of charcoal will not be entitled to much attention, if the reſult ariſing from ſome unpubliſhed experiments made by Dr. Prieſtly may be admitted. That indefatigable philoſopher is ſaid to have converted almoſt the whole of a quantity of charcoal into inflammable air, by throwing the focus of a lens upon it. This fine experiment will very much contribute to ſupport the opinion, that inflammable air and phlogiſton are only different modifications of the ſame ſubſtance; an opinion very ingeniouſly maintained by Mr. Kirwan in a late vol. of the Phil. Tranſ. B.

(h) "If theſe experiments be joined to thoſe related in the Elem. de Chémie. Dijon. vol. i. p. 334. and vol. iii.

E 4

p. 384,

§ XIX. *Fixed Air precipitates Bodies diſ-ſolved in pure Alkalis.*

It is a known property of acids, that they precipitate bodies diſſolved in alkalis; and the ſame may be done by fixed air.

Let,

p. 384, &c. it will be evident that our knowledge of the combinations of fixed air with inflammable ſubſtances, and in particular with oils, is very deficient : it is not, for inſtance, eaſy to comprehend why vegetable alkali cryſtal-lizes, when immerſed in oils, whether eſſential or expreſſèd, without altering their ſenſible qualities ; why cauſtic alkali reduces them to the ſtate of ſoap, while their rancidity ſeems to ariſe from the loſs of fixed air, ſince it is corrected by the reſtitution of this fluid ; and laſtly, why quick lime ſlacks in oils but very ſlowly and imperfectly. The ſolution of theſe problems will certainly lead us to the diſcovery of ſome important truths." Morveau.—The ſolution of the laſt problem would not perhaps be very difficult, if we may aſſume, with Profeſſor Bergman, that in quick lime calcareous earth is united with fixed fire ; and with Stahl, that fixed fire is phlogiſton ; a liberty, however, for which I would not very ſtrenuouſly contend. As oils are already ſaturated with phlogiſton, they muſt be incapable of taking it from quick lime, and therefore this ſubſtance can only loſe ſuch a portion as can be tranf-mitted through the oil into the air. If ſuch an explica-tion of the phænomenon was admiſſible, it would ſeem to follow, that quick lime cannot ſlack in fluids ſaturated with the inflammable principle. *Sed hoc ariolari eſt.*

The reader will not perhaps be diſpleaſed, if I tran-ſcribe the paſſages referred to by M. de Morveau, eſpe-cially as they are to be found in a work not very com-monly to be met with in this country.

" Oils cannot unite with alkalis, unleſs they be per-fectly cauſtic ; but if deliqueſcent alkali be poured into oil, and the veſſel remain for ſome time unſhaken, very

fine

Let sulphur, diffolved in lime-water, be expofed to fixed air in the bottle Q R; immediately the folution grows turbid, depofiting a lime which effervefces with acids, becaufe pure calcareous earth adheres more readily to fixed air than it does to fulphur.

fine cryftals, in the fhape of parallelopipeds with oblique angles, will be formed at the bottom. They form alike in unctuous oil, in effential oil of turpentine, and ftill better in animal oil. Now, as the heavier alkali falls to the bottom of the veffel, we muft infer that there is an affinity between the oil and fixed air ; whether it furnifhes alone that which is attracted by the alkali, or receives, at the furface which is in contact with the atmofphere, a quantity equal to that which it is obliged to yield to the fuperior attraction of the alkali.

" As the rancidity of oils is occafioned by the diffipation of the fixed air that formed a conftituent part of them, this alteration may be prevented by reftoring as much as they have loft. The Abbè Rozios obferves, that if a fpunge, imbibed with a foft pafte of alum and abforbent earth, be kept at the bottom of a veffel containing oil ; as the abforbent earth has a greater affinity with vitriolic acid than clay, a flow decompofition of the alum is effected, and a new falt is formed ; but in every fuch combination a confiderable quantity of air is extricated, which, as it efcapes, will mix with the oil, and prevent rancidity : in like manner rancid oils may be recovered by reftoring the fixed air. M. Sieffert has given a very good procefs, in which he employs air extricated by fermentation : it confifts in mixing with the altered oil $\frac{1}{10}$ of apples, plumbs, or ftrawberries, &c. reduced into a pulp; in fetting this mixture in a place where it will ferment, and affifting it with a little honey, provided fermentation fhould not go on with fufficient rapidity : the oil, if drawn off after this procefs is over, will be not only reftored, but improved ; fince oils naturally acrid may be brought, by this method, almoft to the mildnefs of oil of olives." Elemens de Chémie. Dijon. B.

Hepar

Hepar fulphuris, prepared with fixed al-
kali, is likewife precipitated, but fomewhat
more flowly, as the aerated alkali is eafily
retained by the water, therefore in this cafe
the fulphur precipitates alone; befides if
(as is ufually the cafe) more alkali is prefent
than is fufficient to diffolve the fulphur, no
turbidnefs is occafioned, until the fupera-
bundant alkali is firft compleatly faturated.

The volatile hepar fulphuris, which con-
tains fulphur diffolved in pure volatile al-
kali, and is commonly called the fulphu-
rated fmoaking fpirit of bejuin, is very
quickly and fpeedily rendered turbid by
fixed air. No alkali, except when cauftic,
can attack fulphur; and therefore, upon the
acceffion of fixed air, all the alkalis are ren-
dered unfit for retaining it.

Liquor of flints, in the open air, gradually
depofits its filiceous earth; a depofition
which is quickly effected, if fixed air be made
to float on its furface, and that the fooner,
as the alkali is lefs predominant. This is
the reafon why a folution of alkali of tartar,
although repeatedly filtered, continues for
a great length of time gradually to depofit
earthy flocculi; for this alkali contains, in-
timately mixed with it, flinty particles,
which it has acquired either during vegeta-
tion or combuftion.—The calciners of pot-
afhes fometimes fraudulently add fand, in
order to increafe the weight; which, during
the operation, fo unites with the afhes, that
the

the flinty matter, by means of the alkaline falts, becomes foluble in water along with them.—This flinty matter afterwards gradually feparates, in proportion as the alkali is faturated with fixed air, with which this latter more willingly unites. Now, as the alkali is kept in a bottle with a narrow neck, and generally ftopped, it muft receive the precipitating matter from the atmofphere very flowly.—The feparation therefore proceeds very gradually; but if it be diffolved in a large quantity of water containing fixed air, or if, from the folution having been long made, it is fufficiently loaded with fixed air, the whole earthy matter at once falls to the bottom (i).

Soap

(i) Hence we learn what refpect is due to M. Baumé's opinion, which has been frequently copied into elementary books, concerning the caufe of this depofition: according to him it happens in confequence of a real decompofition of the alkali, of which the conftituent parts are far lefs intimately united than thofe of the acids. A portion of the nearly-pure fire, to which it is indebted for its faline properties, is diffipated, and a proportional quantity of earth is feparated, and falls to the bottom;—this falt may be eafily decompofed, by driving off the air and fire that are among its conftituent parts: at the end of thefe operations the earth and water, the other conftituent parts, may be collected feparately. Chymie Exp. & Raifonn. tom. i. p. 322.—Of M. Baumé's work, whatever merit the experimental part may poffefs, candour muft allow that it is too full of idle fpeculations and groundlefs conjectures; and that the inexperienced reader cannot be put too much on his guard againft being mifled by fuch falfe lights. I was defirous of an opportunity to introduce this caution, and to confirm it by an example,

as

Soap is hardly decompofed by fixed air, partly becaufe the alkali is almoft always fuperabundant, partly becaufe this fubtile acid among all known acids is the weakeft, and is accordingly required in great quantity; for even of common diftilled vinegar no fmall quantity is requifite to feparate the oil from the alkali: the apparent difficulty of this decompofition is alfo occafioned by this, that the fmall oily globules which are gradually feparated, being vifcid, cannot eafily run together in diftinct drops.

Aerated as well as pure volatile alkali attacks copper; and hence it happens that neither in the open air, nor by the addition of vitriolic acid, is this folution made turbid or precipitated.

§ xx.   *The fimple elective Attractions of fixed Air.*

We have feen, in the foregoing fections, that fixed air unites with alkaline falts, with earths, and metals, after the manner of an acid; it remains now to examine the different degrees of intenfity with which it attracts thefe different matters.—I mixed them in their pure ftate with aerated fubftances, and kept them in diftilled water, and in bottles which were immediately

as M. Baumé's Chymiftry has been ftrongly recommended to the attention of Englifh ftudents by Dr. Watfon, in his popular Effays.   B.

clofed,

clofed, left the accefs of heterogeneous mat-
ter fhould render the conclufion ambiguous;
I then accurately obferved fuch changes of
weight and quality as could be fubfervient
to the end propofed.

(A) I added aerated terra ponderofa to
pure vegetable alkali; but after a few days
neither was the former diminifhed in weight,
nor the acrimony of the latter in the leaft
mitigated. Terra ponderofa therefore re-
tains fixed air with greater force than the
vegetable alkali attracts it, which is alfo
confirmed by mixing the pure terra ponde-
rofa with a folution of the fame alkali
aerated; for then the terra ponderofa is in-
creafed in weight, and becomes mild, and the
alkali is rendered cauftic. If vegetable alkali,
perfectly pure, be added to water loaded with
pure terra ponderofa, no precipitation takes
place; but if the alkali be aerated, immedi-
ately a turbidnefs arifes, the alkali is ren-
dered cauftic, and the terra ponderofa pre-
cipitates aerated; but fince, agreeably to its
ftrength (k), terra ponderofa is faturated by
a very fmall portion of fixed air, we muft
determine the quantities to be mixed toge-
ther (§ VII. VIII. X.);—now 100 parts of
aerated vegetable alkali contain as much
fixed air as is fufficient to faturate 390 parts
of pure terra ponderofa, if each of the ma-
terials be difengaged (compare alfo B.)

(k) Vid. Sect. VIII.

All

All the circumſtances juſt now mentioned take place when lime is uſed inſtead of terra ponderoſa, except the proportions, which in this caſe are, that 100 parts of aerated alkali cannot, with its fixed air, ſaturate more than 68 parts of pure lime.

Let 263 parts of mineral alkali, newly cryſtallized, and 100 parts of pure vegetable alkali, be diſſolved together in 300 parts of warm water ; then let the ſolution evaporate over the fire, in a proper veſſel ; and let the pellicles which ſucceſſively appear on the ſurface be taken away, and collected in a cone of filtering paper, ſo as to be freed from the adhering cauſtic liquor ; and let this be continued until the pellicles make up from 150 to 200 parts ; theſe, upon examination, are found to be the true vegetable alkali aerated ; and the remaining lixivium contains the mineral alkali in a cauſtic ſtate : hence we may eaſily form a judgment concerning the ſuperiority of attraction between the vegetable and mineral alkalis.

93 parts of aerated volatile alkali give over their fixed air to 100 parts of pure vegetable alkali, and aſſume a cauſtic nature, but the latter portions are more ſlowly decompoſed.

168 parts of aerated magneſia contain only ſo much fixed air as is ſufficient to ſaturate 100 parts of pure vegetable alkali.

We

We have already obferved, that metals diffolved in water by means of fixed air are precipitated by cauftic vegetable alkali.

(B) What has been already faid of the vegetable alkali holds good with refpect to the mineral, with relation to terra ponderofa, lime, volatile alkali, magnefia, and metals, only changing the proportions; but it is in general to be obferved, that the numbers coming out in any cafe, according to the principles already eftablifhed, only indicate accurately how much fixed air is fufficient to faturate the fubftance employed, when at liberty; but as the operation proceeds much more eafily at the beginning than at the latter end, the compleat refolution frequently requires double, triple, or even fix times the quantity of the decomponent.

(c) Volatile alkali furrenders its fixed air not only to terra ponderofa, lime, and fixed alkalis, but even to pure magnefia; for this laft, being added to a folution of aerated volatile alkali, requires the power of effervefcing, and renders the alkali pure.

(D) Aerated terra ponderofa, fo far as I have yet been able to obferve, neither is itfelf changed, nor occafions any change in lime-water; but when burned and diffolved in water it fomewhat obfcures the tranfparency of the calcareous fpar added to it, but the difference of the attractive force of thefe bodies is fo fmall, that the prevalence of the terra ponderofa is not yet quite free from doubt.

doubt.—Magnefia moſt certainly gives out its fixed air to terra ponderoſa.

Terra ponderoſa, diſſolved by ſuperabundant fixed air, is precipitated by all alkalis, by pure lime, and pure magneſia ; all which bodies, by abſorbing the ſuperabundant menſtruum, reduce the terra ponderoſa to exact ſaturation, in which ſtate it is indiſſoluble in water, § x.

(E) If aerated magneſia be put into water loaded with pure lime, it ſoftens the acrimony of the lime-water, and a lime, poſſeſſing the property of effervefcing, is at length found at the bottom, together with pure magneſia. Lime, diſſolved by means of the ſuperabundant fixed air, exhibits the ſame phænomena as the terra ponderoſa in the ſame ſtate, for the menſtruum when ſuperabundant adheres more loofely than when it is only ſufficient for ſaturation.

(F) Pure magneſia is not foluble in water, fo far as is yet known, but if it be taken up by means of fixed air, it is precipitated by alkalis, terra ponderoſa, and lime. When they are cauſtic, the precipitate is fometimes pure, fometimes aerated, in proportion to the quantity of the precipitant ;—for the ſmall portion which can be ſaturated by the ſuperabundant fixed air, reduces the magneſia to a ſtate of ſaturation; fo that, being rendered indiſſoluble, it falls for the moſt part to the bottom, unleſs the quantity of water be large ; and even the pure

pure volatile alkali is able to effect this pre-
cipitation (§ XII.), although inferior in at-
tractive power (C). Terra ponderofa and
lime applied in the fame way, being them-
felves faturated, fall in like manner to the
bottom ; but if the firft mentioned fubftan-
ces be added in fufficient quantity to the
magnefia, they not only feize the fuperabun-
dant fixed air, but alfo that which is necef-
fary to faturate the magnefia, which there-
fore, in this cafe, is precipitated pure (G).
Metallic bodies diffolved by fixed air (§ XIV.
— XVI.) are precipitated by alkalis, or
earths when cauftic. As to zinc, its fo-
lution, like that of the reft, grows turbid
with pure volatile alkali ; but being gently
fhaken the clouds again difappear, becaufe
the volatile alkali eafily diffolves this femi-
metal.

Alkalis fully aerated, as alfo magnefia and
lime in the fame ftate, do not at all difturb
the metallic folutions, when newly made ;
but if they be expofed either to the open
air or to heat, fo that part of the fixed air
fhall have flown off, and the remainder ad-
here but flightly, a feparation is occafioned,
owing to the flight connection which now
takes place between the metals and the
water.

It is well known that zinc precipitates
all the other metals from menftrua ; and
that this would, in the prefent inftance, take
place, I have no doubt, provided the quan-

F   tity

tity of fixed air could be fo adjufted as to be fufficient only to diffolve one of the metals; but this can hardly be hoped for: fo long therefore as the menftruum is fufficient for diffolving two or more together, neither any feparation or precipitation will be obferved. I have added filings of iron to folutions of zinc, both in the ftate of regulus and of calx; and again, to folutions of iron I have added zinc, and after fome days I have found the metals laft added partly diffolved, without any feparation of the former. It may therefore be afked, why the aerated water does not take up the former to faturation, as we find that it can afterwards attack the latter? The following explanation appears to me to be moft fatisfactory: — Aerated metals are falts extremely difficult of folution, fo that by experience we find that only a very minute portion of them can be taken up by water; water, however, when faturated with one falt, not only does not refufe to take up more, but the prefence of many encreafes their mutual folubility; which may be illuftrated by feveral examples; thus, when faturated with nitre, it will not only take up common falt, but, being fully faturated with the latter, will again diffolve more nitre. In the prefent inftance this is the lefs wonderful, as we know for certain that the firft metal leaves untouched a fufficient quantity of the menftruum (fixed air) for the folution of the latter.

If

If therefore a table of affinities is to be drawn up for the metals, we have no reason for departing from that which belongs to the other acids ;—that namely which has zinc first, manganese next, and last iron.

We deduce therefore, from the preceding experiments, the following table of elective attractions.

Aerial Acid.

pure terra ponderosa
---.. lime
---.. fixed vegetable alkali
---.. fixed mineral alkali
---.. magnesia
---.. volatile alkali
zinc
manganese
iron.

(h) With respect to the acids hitherto known, the aerial appears to be the weakest, for it is expelled not only by vinegar, but by the phlogisticated acids of nitre and vitriol. In the mean time, however, I have more than once seen water loaded with the very purest fixed air (which had been extricated by fermentation, fire, or nitrous acid) grow turbid with a solution of lead in vinegar ; yet, although at other times I had disposed the quantities of the ingredients, and every other circumstance, in the same way, no vestige of turbidness appeared. It is known that boiling vinegar takes up ceruffe,

and

and expels its fixed air.   Perhaps, then, old
cryftals lofe by age a part of the vinegar ;
perhaps they are decompofed by abundance
of water, fo that the aerated water can take
up the calx of the lead, and with it form a
falt which altogether rejects water, but is
diffolved again in the vinegar, without any
vifible effervefcence.—I leave this queftion
undecided, until I can explain the caufe of
difagreement between thefe experiments : I
do not make ufe of the vitriolic acid, as the
very fmalleft mixture of that acid precipi-
tates acetated lead.

§ XXI.

Pure volatile alkali cannot precipitate
either terra ponderofa, lime, or magnefia,
diffolved in any common acid, but aerat-
ed volatile alkali can effect fuch precipita-
tion very readily ; hence, although the for-
mer, by many experiments, plainly appears to
be the ftronger, yet fome perfons, from this
circumftance (the true reafon of which they
do not underftand) think it weaker.   But
the truth is quite otherwife ; namely, the
volatile alkali attracts all acids with much
lefs force than lime (I take this inftance only
by way of example) therefore, when that
falt is pure or alone, no decompofition takes
place ; but if it be impregnated with fixed
air, then a fourth fubftance is added which
attracts the lime, fo that the calcareous falt
is acted upon by a double force ; one the at-
traction

traction of the pure alkali, foliciting the acid, the other that of the fixed air for the lime; and thefe forces joined together overcome the original adhefion of the lime with the acid.

The fame is to be faid of aerated magnefia, which in like manner decompofes calcareous falts.

Befides, although pure fixed alkalis can feparate acids from many earths, and from metals, it does not follow, that this procefs may not be performed by a double decompofition, when the alkalis employed are aerated. Hence that remarkable difference of weight which is often obferved in precipitating the fame fubftance. Let 100 parts of calcareous fpar be diffolved in an acid; thefe, precipitated by cryftallized fixed alkali, being accurately collected, wafhed, and dried, yield nearly 100 parts again, fimilar in their nature and properties to crude lime. But if the operation be performed with pure alkali, the precipitate will not be more than 0,55, and agrees in properties with burned and flacked lime; and the fame is true of all fubftances which in their natural ftate abound with fixed air. Metals indeed differ in this refpect, yet they too gain from aerated precipitants a confiderable increafe of weight; for inftance—mercury $\frac{1}{7}$, iron nearly an equal weight, and fo on. Silver diffolved in nitrous acid is more eafily precipit̶ ̶ by aerated than by cauftic alkali,

and

and the precipitate is heavier.   Thefe accef-
fions of weight are to be attributed to the
fixed air, which being expelled by the ftronger
acid, adheres to the deferted metal, and, ac-
cording to its quantity, alters not only the
weight, but fometimes even the colour. We
faid before, that pure vegetable alkali pre-
cipitates corrofive fublimate of a ferruginous
colour, but when fully aerated of a white
(§ vii.) : we faid alfo that the mineral alkali
can never produce a white calx of mercury
(§ viii.), let us now fee the reafon.

Let there be precipitated only fo much as
is united with 100 parts of marine acid, and
let the precipitation be made with vegetable
alkali, fully aerated, for which purpofe
about 415 are neceffary; for 100 parts of
marine acid require 199 of pure vegetable
alkali (§ viii.), and thefe 199 can receive 84
of fixed air, and 132 of water (§ vii.) ; but
if the mineral alkali be ufed, 100 parts of
marine acid require only 80 parts of alkali ;
which in cryftallization receive 64 parts of
fixed air, and 256 of water : fince, therefore,
the mercurial calx, in this inftance, requires
84 parts of fixed air to be made white, and
the mineral alkali fufficient for the pre-
cipitation can fupply only 64, it appears
plainly why this alkali cannot throw down
a white precipitate (/).

It

(/) " In order to compleat the proof of this fine theory,
it would perhaps be requifite to fhew that the quantity of
mercury

It is very probable that even the calxes of the bafer metals, although prepared by fire, are not altogether void of fixed air.—With refpect to old flowers of zinc, I entertain no doubt, as they effervefce with acids, and yield a vapour endowed with all the properties of fixed air; when newly made, they fcarcely excite any fenfible motion; and even the old ones, by roafting, are deprived of that volatile menftruum which they had attracted from the atmofphere. The fame holds of old ceruffe — new ceruffe I have not yet examined (*m*).

mercury which may be combined with 100 parts of marine acid, takes up more than 64 parts of fixed air, when it is precipitated by cryftallized vegetable alkali; for, it is not eafy to prefume that this really happens, when it is confidered that the author has juft afferted that this metal gains, by fuch a precipitation, an addition of only one third of its weight. It may be moreover obferved, that feveral phænomena indicate the prefence of a quantity of phlogifton in the intimate conftitution of foffil alkali. I have fhewn that it reduces gold, in the fame circumftances in which vegetable alkali affords only an earthy precipitate.—(El. de Chem. Dij. tom. ii. p. 310.) Now the colour of the mercurial precipitate may be explained juft as fatisfactorily by this hypothefis." Morveau.

(*m*) " This obfervation is of great importance, as it announces a metallic earth, free from all combination, either with phlogifton or the aerial acid; and as it furnifhes the firft exception to this general rule, That the metals do not lofe their *metallizing* principle, but to unite with another menftruum, and reciprocally." Morveau.

§ XXII. *Fixed Air is a true Acid.*

From the foregoing experiments, we may conclude concerning the agreement of fixed air with acids; for, from them it appears that this vapour excites a diftinct fenfation of tafte upon the tongue (§ v.); that it reddens tincture of turnfole (§ vi.); that it attacks fixed alkalis violently, and renders them mild; that a fmaller quantity of it than of the ftronger acids faturates them, renders them cryftallizable, and lefs foluble (§ vii, —viii.); that by its union it makes volatile alkali more fixed, lefs odorous and penetrating, and cryftallizes it (§ ix.); that when it juft faturates pure lime, it takes away its folubility and acrimony, and cryftallizes it, but that when fuperabundant, it renders it again foluble (§ xi.); that it produces the fame effects with terra ponderofa (§ x.); that with magnefia, it conftitutes a neutral cryftallizable earthy falt (§ xii.); that with iron, zinc, and manganefe, it forms falts, which, when diffolved in water, redden the tincture of turnfole, like all other metallic falts (§ xiv.—xvi.); that it exerts elective attractions, both fimple and double, after the manner of acids (§ xx. xxi.); that it precipitates fubftances diffolved in pure alkalis (§ xix.); that its laft particles, notwithftanding its extraordinary volatility, adhere very tenacioufly to boiling water,

<div align="right">and</div>

and are not without great difficulty entirely
feparated from it, but that by congelation
they are eafily detached, in the fame manner
as by that fame degree of cold the weak acids
are concentrated (§ IV.); and finally, that
it greedily attracts phlogifticated matters
(§ XVIII.). Every one of thefe properties
belong to acids in general, and moft of them
are confidered as characteriftic marks which
are peculiar to acids, and diftinguifh them
from all other fubftances: either then, fixed
air, being endowed with all thefe qualities,
is an acid, or we are reduced to confefs that
no certain criterion of acids is yet known.

The acidity of fixed air being, as I think,
demonftrated, many reafons induce me to
apply to it the name of aerial, or atmo-
fpheric acid, as being adapted to its nature.
It fo much refembles common air in levity,
tranfparency, elafticity, and other properties,
that it is only of late they have begun to be
diftinguifhed.—Befides, in that aerial ocean
which, under the name of atmofphere, fur-
rounds our globe, this vapour is continually
prefent, either free or entangled in combina-
tion with other bodies. Its exiftence in the
former ftate is manifeftly feen in phæno-
mena which daily occur; lime-water every
where feparates a cream, when expofed to
the open air, which does not happen in bot-
tles perfectly clofed; and never can happen,
unlefs fixed air be in contact with its furface
(§ XI.). Quick lime, expofed for a long
time

time to the atmofphere, by degrees recovers
what it had loft in the fire, fo as entirely to
re-affume the nature of crude lime, and be
unfit for the mafon's ufe, unlefs it be again
deprived of its acid. Terra ponderofa and
magnefia, reduced to a ftate of purity, in like
manner recover from the open air their
weight, power of effervefcing, and other
loft qualities. Pure alkalis are made mild in
the open air, lofe their deliquiating quality,
and form cryftals which effervefce with
acids, circumftances which can only be af-
cribed to their attracting fixed air. Since
then, thefe phænomena all take place at
every time, and in every part of the world,
a quantity of uncombined fixed air, by no
means inconfiderable, muft be perpetually
prefent in the atmofphere.

But it is not only in an elaftic and difen-
gaged ftate that fixed air furrounds us, but
it alfo feems to conftitute a primary principle
of common air. This ingenious conjecture
of the indefatigable Dr. Prieftly comes now
to be examined.

The experiment indicating this compofi-
tion of atmofpheric air, is as follows :—Let
tincture of turnfole include a bubble of com-
mon air in a glafs tube, bended into the form
of a fyphon ; let either leg, filled to a certain
height with mercury, be immerfed in a veffel
filled with that fluid metal ; then, by means
of an electrical machine, let ftrong fparks be
plentifully paffed from the mercury in one

2   leg,

leg, through the bubble in the other. This
being continued for some minutes, the fur-
face of the tincture will be found to rife
higher in both legs, and to change its blue
colour to a red; the tincture, thus red-
dened, recovers its blue colour in the open
air. If, inftead of the tincture, lime-water
be ufed, it is rendered turbid, and depofits
an effervefcing lime. In this cafe then, the
air feems to be decompofed, and to be di-
vided into two different elaftic fluids, one of
which tinges the tincture of turnfole with a
fugitive red, is abforbed by water, and preci-
pitates lime-water, that is, is endowed with
all the criteria of fixed air; but the other
fluid does not combine with water, ex-
tinguifhes flame, and deftroys animal life,
as it fuffers no change from the vapour of
phlogifticated nitrous acid. That thefe phæ-
nomena do not depend upon the electric
fluid alone, appears plainly, for if, by means
of an air-pump, the bubble of air be fo di-
lated that all the reddened tincture is ex-
pelled from the legs of the fyphon, and in
its place a blue tincture be poured in, to the
fame height, then, though the fparks be
paffed through the bubble, as before, no vef-
tiges of fixed air appear. Hence then it ap-
pears, that fomewhat which reddens tinc-
ture of turnfole, and precipitates lime-water,
is found in the air, and has been taken away
in the former operation.

We now know that common air confifts

of

of three elaſtic fluids mixed together ; viz.
1ft, of the aerial acid, in its diſengaged
ſtate, but in ſo ſmall a quantity, that it
alone cannot impart a viſible redneſs to
tincture of turnſole ; 2d, of an air unfit for
ſuſtaining flame, or being ſubſervient to re-
ſpiration (this we may call vitiated air (*n*),
until we are better acquainted with its nature
and properties) ; and 3d, of air indiſpenſably
neceſſary to flame, and animal life, which
forms only about one fourth of common
air, and which I call pure air. Here a queſ-
tion may ariſe, which of theſe fluids has
been altered by the electric aura ? I am in-
clined to think the latter, inaſmuch as it
attracts phlogiſton more violently than even
the nitrous acid does : let us now ſuppoſe
this air compounded of two principles,
namely, of the aerial acid, and ſome other
ſubſtance, which unites more readily with
the electrical phlogiſton than with the aerial
acid ; when the electrical phlogiſton there-
fore is added, the aerial acid is ſeparated,
and, as it were, precipitated. Although all
this appears very probable, yet other expe-

(*n*) The nature of this elaſtic fluid, which Dr. Prieſtly
has denominated *phlogiſticated*, ſeems to have been leſs
elucidated than that of almoſt every other ſpecies. It is
generated by phlogiſtic proceſſes, and immerſion of ani-
mal ſubſtances in nitrous acid : it is ſpecifically lighter
than atmoſphæric air ; is fatal to reſpiring animals, though
ſome inſects live in it ; it is reſtored by vegetation, and in
ſome degree by agitation, in orange-coloured nitrous
acid. B.

riments, in which, by means of phlogifton, air is changed, without any appearance of the extrication of fixed air, prevent us from concluding with certainty concerning the compofition of the air. Let us ufe, as an example, the fulphurated falt of Stahl. I expofed ftrips of linen, wet with cauftic vegetable alkali, for a fufficient time to the fumes of burning fulphur; I then put them into different cucurbits, and preffed them to the bottom, fhut the mouths very clofely with wet bladders, and kept them in an heat of about 18° for 16 days;—at the end of that time I opened the mouth of one cucurbit under the furface of tincture of turnfole, which immediately rufhing in, filled a little more than $\frac{1}{5}$ of the cavity : hence, therefore, it appears, that the phlogifton had by degrees deferted the vitriolic acid, and changed the included air, yet no rednefs could be perceived in the tincture. I opened the mouth of another cucurbit, under limewater, which entered in the fame manner, but fhewed no figns of turbidnefs (*o*). If electrical

(*o*) Was the fixed air produced in this experiment abforbed by the vitriolated tartar, as it was gradually formed, in confequence of the diffipation of the phlogifton ?—Perhaps this conjecture will not appear fo very improbable, if we confider that Dr. Prieftly obtained from $\frac{1}{2}$ an ounce of that neutral falt $1\frac{1}{2}$ ounce meafure of air, chiefly fixed; vol. ii. p. 116.—See alfo vol. v. p. 164, where he fays that he procured fixed air mixed with another fpecies of elaftic fluid, both from vitriolated tartar and Glauber's falt.

M.

electrical fparks extricate fixed air, purely by the addition of phlogifton, why does not the fame extrication take place in this laft experiment ?—It is indeed true, that in the former cafe the electrical phlogifton pene-trates the whole mafs much more violently, and thence may perhaps decompofe fome primary principle; and perhaps if the cir-cumftances of our experiment were charged, the fame effect will be produced; but the laws of found reafoning oblige us to fufpend our judgment until a number of apt experi-ments fhall determine the truth.

In the mean time fixed air may with great propriety be called the aerial, or (if more agreeable) the atmofpheric acid; it might alfo be called the univerfal acid, as it is found in great abundance throughout all nature: but as it is ufual by that denomi-nation to indicate that faline principle which, differently modified, produces all the other acids and alkalis; and as thefe

M. Morveau contends, that the experiment above re-lated only proves that fixed air is produced by the elec-tric fpark taken in common air; and that, when a given quantity of air has been once expofed to the influence of that fluid, no more fixed air is produced by frefh fparks. He inclines to think that fixed air is generated by the combination of fome other principle with pure air. Thofe who adopt the opinion fo ingenioufly maintained by Mr. Kirwan, in vol. lxxii. of the Phil. Tranf. that fixed air confifts of dephlogifticated air and phlogifton, will readily fuppofe, that the fixed air is generated, not difen-gaged, by the electrical fire. B.

properties

properties cannot as yet be affirmed of fixed air, I think we fhould abftain from that name, as being ambiguous. I am not ignorant that the volatile alkali, and the marine acid, contain phlogifton as one of their primary principles; and that, being fpoiled of the inflammable principle, they are refolved into elaftic vapours : but the vapours which are in both cafes obtained, although not condenfable by cold, are not of the fame nature, and neither of them is fimilar to fixed air. The vitriolic acid, which is fuppofed to be contained in the atmofphere, is neither every where, nor at all times, to be found there : I have for feveral years, by means of the pureft fixed alkali, endeavoured to obtain it, but have not as yet obtained a fingle particle. The vegetable alkali often contains vitriolated tartar, and the alkali of tartar itfelf is not always free from it, owing doubtlefs to the practice of fumigating wine-veffels with fulphur—unlefs, therefore, the purity of the alkaline falt which is expofed to the air, be well known, errors can fcarcely be avoided: the vitriolic acid, therefore, is not prefent in the atmofphere, unlefs accidentally; the fame may be faid of the nitrous and marine acids, which are fometimes found in it.

§ XXIII. *Whether Acidity be effential to fixed Air.*

Although I imagine I have eftablifhed beyond

yond doubt the acid nature of fixed air, yet
some persons may suspect that this acidity
is accidental, and to be ascribed to a foreign
acid, which is intimately united, by way of
solution, with the common air;—but I hope
the following observations will shew that
this opinion is entirely without foundation.

(A) Let us suppose that common air,
extricated from lime by vitriolic acid, is,
notwithstanding the washing, contaminated
by that foreign acid, in such a way that they
can hardly be separated; and that, while this
union lasts, the air is rendered fixed;—now
let lime-water be saturated with this elastic
fluid, and the precipitated lime examined, it
will be found in all respects similar to cream
of lime, or crude lime.—I would ask, whe-
ther the common air, when it is again joined
to the pure lime, retains the acid adultera-
tion, united to it in the same manner as be-
fore? or, whether it shakes it off, and leaves
it at liberty to unite with other matters? If
the former be asserted, either the lime pre-
cipitated by fixed air ought to differ from
common lime, which contains no vitriolic
acid (a supposition contradicted by the most
accurate chemical examinations) or the dif-
tinction between fixed air and common air
is reduced to nothing; which overturns the
hypothesis of the generation of fixed air:
if the latter, distilled vinegar would dissolve
the precipitated lime, leaving the gypsum
untouched; but experiments made with the

<div align="right">greatest</div>

greateft accuracy fhew that diftilled vinegar diffolves the whole of the precipitate.

(B) Again, if the acidity depends upon a foreign admixture, different fpecies of fixed air fhould be produced by different acids. Now experience fhews, that fixed air, extricated by marine acid, and properly wafhed, precipitates lime-water in the fame manner with that obtained by vitriolic acid; and finally, that not the flighteft difference in any of its properties can be difcovered, whatever acid it is extricated by, provided it be fufficiently depurated by wafhing. If the fixed air obtained by vitriolic acid poffeffes, on that account, the property of diffolving iron and zinc, that procured by the nitrous ought to attack filver and mercury; that by aqua regia, gold and many other metals;—but experiments, which I made myfelf for that purpofe, fhewed me that no fuch thing happens.

(c) Befides, grant that the fixed air expelled during effervefcence is adulterated by an acid, whence does that which is produced entirely fimilar by fermentation gain it; efpecially that which appears in the beginning, a long time before even the firft ftage of fermentation has attained its height? If the acidity of fixed air be foreign, why can it not be fo accumulated as to redden fyrup of violets, paper tinged with turnfole, and the other vegetable blues?

G   (D) Finally,

(D) Finally, calcareous fpar and mag-
nefià afford genuine fixed air, purely by the
force of fire (§ 11.) ; although, by the moft
fcrupulous examination, they do not betray
the fmalleft veftige of a mineral acid.   And
this fixed air is produced, although they
have been very minutely powdered and
boiled for half an hour in a pure alkaline lixi-
vium, and afterwards wafhed and dried, be-
fore they are put into the retort;—thus then
all fufpicion of a foreign acid vanifhes.

Since then, fixed air, rightly depurated,
though extricated by the moft different
means, from the moft different materials,
whether by fire or by folution, is never-
thelefs always the fame, and always acid; I
conclude, with all the certainty attainable
in phyfics, that acidity is a property effen-
tial to that elaftic fluid.

Some confider fixed air as the fame with
the vapour of phlogifticated vitriolic acid ;
yet any one who but flightly compares the
properties of the two, will eafily fee that this
opinion is without foundation—for the one
has an irritating pungent odour, and deftroys
the colours of any organized fubftance ; and,
to pafs over other circumftances of moment,
may eafily be reduced to genuine vitriolic
acid, neither of which is true of fixed air,
which poffeffes a much lefs powerful at-
tractive force than the other.

§ XXIV.

§ XXIV. *Specific Gravity of the Aerial Acid.*

By means of an hollow globe I meafured the fpecific gravity of fixed air in the fame way as natural philofophers weigh common air.—I compared the weights of equal bulks of fixed air and diftilled water three feveral times. The firft time I found the proportions as 1 to 555; the fecond, as 1 to 563; and the laft, as 1 to 560. I employed, as nearly as I could, a moderate heat (15°) together with a mean height of the barometer (25,3) but yet could not avoid fome minute differences.—The medium of the three obfervations is $559\frac{1}{3}$, or, in round numbers, 559—fo that its fpecific gravity comes out 0,0018;—now common air, in the fame circumftances, is fcarcely 0,0012—fo that fixed air is about 0,0006 heavier than common air.

The noxious vapour which abounds in certain caverns is entirely of the fame nature as the aerial acid, for it is abforbed by water, and communicates to it a pungent acidity; it reddens tincture of turnfole, makes lime-water turbid, extinguifhes flame, kills animals, and, above all, rifes but a little way, on account of its fpecific gravity. In a pit which was opened in the year 1717 at the Pyrmont Spa, the loweft ftratum of air, which is fcarcely two feet in depth, is

noxious,

noxious, and when the fun's rays can reach down to it, it may be perceived, by means of the exhalations mixed with it. Over the medicinal fountain itfelf there is a poifonous ftratum of air hardly a foot in depth, fo that geefe, by means of their long necks, can fwim acrofs it without damage. The exhalations from the caves in the neighbourhood of the Swalbach, and other acidulous waters, are of the fame nature. In the Grotto del Cane, near Naples, men, and even large dogs, fuffer nothing while they ftand erect, but if the noftrils of any animal are brought near the ground, it is inftantly feized by ftupefaction.—This deadly vapour may be feen like a very fubtile fmoak, which in fummer rifes about a foot from the ground ; but in winter not above a few inches.

From the gravity of fixed air it alfo follows, that the lower ftrata of the atmofphere abound more with it than the higher; for the prodigious quantity which is generated by fermentation, putrefaction, effervefcence, and other natural operations, every day going on, for the moft part remains clofe to the furface of the earth;—this muft be again fixed by the continual generation of new bodies. Certain portions of it alfo, which are perhaps generated from the common air, in the higher regions of the atmofphere, by lightning and by various meteors, muft by degrees all fubfide, were it not that the continual agitation of the atmofphere,

mofphere, mixing the common air and aerial acid with each other, together with the friction and the fmallnefs of the difference in fpecific gravity, contribute much to prevent it : which, together with the above-mentioned diminution of it, all contribute to avert deftruction from the animal world. Hence I imagine the reafon is plain why higher fituations are in general more healthful than lower ones (p); and I have no doubt but that various diforders, both epidemic

(p) Though elevated fituations may in general be more falubrious than low ones, it is not to be fuppofed that the healthfulnefs of any place is in proportion to its elevation, on account of the different quantities of aerial acid to be found in different ftrata of the atmofphere. But it is not unufual with thofe who are contemplating one of the principal agents in nature, to afcribe too many effects to it. M. Sauffure found that the air of the valley of Chamouni abforbs a volume of nitrous air equivalent to 28 grains of water more than the air at the fummit of the Buet. Three other experiments concurred with this to fhew that the air of the fummits of mountains is lefs pure than that of the vallies lying at the foot of them. The air on the glacier of Taléfre alone appeared, by the nitrous teft, fuperior to that of the valley of Chamouni. The air of Geneva was of equal goodnefs with that of Chamouni, and fuperior to that of the plains of Piedmont.

"Since then," fays M. Sauffure, "of the tops of five mountains, four afforded an air lefs pure than the plains lying at their feet; and the only one on which the air is more falubrious than in the plains, owes that advantage to a particular fituation ; it feems as if we may conclude that the air, at a certain height, lofes fomewhat of its purity.

"I fhould, however, have been more cautious than to deduce a general conclufion from fo inconfiderable a number of obfervations, if the fine experiments of S. Volta on

G 3   inflammable

demic and endemic, arife from the different quantities of aerial acid in the atmofphere. At the furface of the earth it is rarely found to form $\frac{1}{16}$ of the common air.

The aerial acid is not always of the fame degree of tenuity, which feems to depend upon this, that water abforbs certain particles more readily than others. It is not wonderful that the union fhould be continually retarded from beginning to end, as this effect is entirely conformable to the nature of attraction ; yet the following phænomenon feems to confirm the former opinion :—

Let us fuppofe the bottle Q R filled with fixed air, and one half of it by degrees confumed. A fubfequent union will be effected, in a given time, more flowly with the remainder, than with fixed air which had not been expofed to water, though the furface of contact be the fame. Hence it

inflammable air had not proved, that an immenfe quantity of this elaftic fluid is conftantly produced, which, as it is much lighter than common air, muft rife to the more elevated regions of the atmofphere.

" It appears, therefore, that if the air of the low plains is rendered lefs falubrious by the grofs exhalations which its denfity enables it to fupport ; on the other hand, the air of mountains raifed more than 500 or 600 fathoms [toifes] above the level of the fea, is vitiated by other exhalations, which do not lefs diminifh its wholefomenefs, becaufe they happen to be lighter than common air ; fo that, even in the prefent inftance, there is a certain medium, at which the denfity of the air, *ceteris paribus*, is beft adapted to the life and health of man—I fhould fix the height at that of the plains and great vallies of Switzerland, which are elevated between 200 and 300 fathoms above the level of the fea." B.

would

would appear, that certain particles, either by reafon of their figure, their magnitude, or fome extraneous mixtures, are rendered more unfit for union with water (*q.*)

§ xxv. *Aerial Acid extinguifhes Fire.*

Fixed air not only prevents fire from being kindled, fo as to prevent the explofion of bombs and fire-arms, but it alfo inftantly and completely extinguifhes a body red hot, and flaming; fo that to determine the prefence of mephitic air by flame is a common experiment.

If a glafs cylinder, A D, filled with aerial acid in the manner above defcribed (§ 11.), and then ftopped by a cover, be carefully inverted and opened, the fluid contained will, by its fpecific gravity, remain there; let then a lighted candle or coal be immerfed in it, and in an inftant all the fire will be extinguifhed. But if the veffel remain open, the upper ftrata mix gradually with the common air, fo that flame can at length fubfift in them; and in this manner, by degrees, the whole mafs is changed, but the more flowly in proportion as the cylinder is more lofty, and the circumjacent air more tranquil. The fame phænomenon may be obferved on the furface of fermenting liquors.

(*q*) " Difference of figure between elementary particles feems repugnant to the theory of affinities, as produced by this figure; for it is evident that a body not having the fame affinities has not the fame properties, confequently cannot be the fame body. I therefore think the laft-mentioned caufe the only one admiffible. Morveau."

The

The aerial acid very ftrongly attracts fmoak, extends it in a ftratum parallel to its own furface, and holds it a long time. This may be obferved in caverns where mephitic air is produced by means of the fmoak of an extinguifhed torch, or a gun fired over the noxious ftratum.

§ XXVI. *Aerial Acid kills Animals.*

In thefe experiments I generally employ the following apparatus:—A glafs veffel, A B (fig. 9.) when the animal is enclofed, is fuddenly cemented to the wooden bottom, B C; this veffel is perforated at the top by a hole, D; the tube, E F, which introduces the noxious vapour is fitted clofely to the bottom, fo that no air can efcape; the noxious vapour expels the lighter common air through the hole D; at firft, however, they are in fome degree mixed together, which is the reafon why the animal does not as quickly die as when at once immerfed in the aerial acid: but experiments have fhewn me, that by this very circumftance the phænomenon may be more eafily diftinguifhed.

As foon as the noxious vapour rufhes in through the tube E F, the animal looks about with great anxiety, in order to efcape; it then begins to pant—the eye-balls are protruded — it trembles — and at length expires as if going to fleep. By regulating the influx of aerial acid, the approach of death may at pleafure be deferred. The difference in the fpecies of animals, their age and vigour,

make

make fome difference : thus birds general-
ly die fooner than dogs ; thefe fooner than
cats ; amphibious animals endure longer ; and
infects longeft of all. With refpect to age,
the younger animals are lefs quickly de-
ftroyed, efpecially thofe that are fomewhat
accuftomed to it ; for fuch as have been
often expofed to the open air in the very
agony of death, and recover, are afterwards
more flowly deftroyed by that fluid than
fuch as are for the firft time expofed to it.
After death, the lungs appear fomewhat
collapfed ; they do not fink in water, like
thofe of an animal which has perifhed in
vacuo, but float ; and often are in many
places inflamed. The trunk of the pulmo-
nary artery, the right ventricle of the heart,
with its auricle, the vena cava, the jugular
veins, and the veffels of the brain, are dif-
tended with blood ; and I have more than
once feen a firm polypus in the right ven-
tricle. The pulmonary veins, the aorta, the
left ventricle of the heart, with its auricle,
are generally flaccid. The irritability of the
mufcular fibres all over the body is found
deftroyed : nor could I, either by blowing
into it, by the knife, or by vitriolic acid
highly concentrated, excite to motion the
heart of an animal thus deftroyed, although
taken out warm.

Authors difagree concerning the effective
caufe of death in this cafe ; and it would be
prefumption in me to attempt the decifion
<div align="right">of</div>

of fo important a queftion.—Contented if I
have been able, in this Effay, to eftablifh
the acidity of fixed air, which was my chief
purpofe, I have adapted all the experi-
ments to the end propofed with as much
accuracy as I was able ; I repeated them di-
ligently, and confidered them carefully ;—I
therefore thought it unneceffary to particu-
larize thofe which have been made by other
perfons, and for purpofes different from
mine, efpecially as they cannot efcape the
obfervation of the learned reader (*r*).

(*r*) Mr. Bewly, in fome letters, dated towards the clofe
of the year 1775, and publifhed in the Appendix to Dr.
Prieftly's 2d. vol. defcribes a feries of experiments, under-
taken in order to prove the propofition maintained in the
foregoing Differtation. It will appear a little ftrange, that
he fhould not have been apprized of Profeffor Bergman's
opinion on the nature of fixed air (for if he had known it,
his candour would not have permitted him to pafs it over
in filence) as it had been publifhed by Dr. Prieftly, three
years before the date of Mr. Bewly's experiments. We
are therefore to confider the prefent inftance as a confir-
mation of the obfervation, that the fame difcovery is often
made by different perfons, without any communication
with each other, when fcience has arrived at a certain
pitch of maturity. Of this truth Mr. Scheele's difcovery
of dephlogifticated air, without knowing that Dr. Prieftly
had previoufly obtained the fame elaftic fluid, furnifhes
another ftill more remarkable example. On comparing
the dates it will be found, that priority of claim as evi-
dently belongs to the Swedifh profeffor in the former,
as it is acknowledged to belong to our induftrious coun-
tryman in the latter cafe. On perufing Mr. Bewly's ob-
fervations, it will be feen, that he was alfo led to adopt
another opinion, advanced by Sir T. Bergman, and
called in queftion by M. de Morveau, viz. That fixed alkali
is capable of uniting with a quantity of aerial acid ex-
ceeding that which is neceffary for its faturation. B.

II.

OF THE

ANALYSIS

OF

WATERS.

§ 1. *A brief History of the* ANALYSIS *of* WATERS.

MUCH time could not have elapsed,
before mankind firſt began to per-
ceive the difference of waters, although fur-
niſhed with no other criterion than that of
taſte. But the preparation of food, and the
various arts and manufaƈtures which after-
wards began to be ſtudied, muſt gradually
have ſuggeſted a difference in the properties
and goodneſs of waters, with reſpeƈt to cer-
tain purpoſes, although we are at preſent
ignorant of the manner and order in which
theſe diſcoveries occurred. Hippocrates
judges thoſe waters to be moſt proper for
<div align="right">common</div>

common ufe, which are clear, light, void
of tafte and fmell, and which run from the
eaft ; obfervations, the juftice of which is to
this day generally acknowledged, with the
exception of the laft, which perhaps, in the
country of Hippocrates, refted upon fome
local advantage. He (a) condemns, as worft
of all, fuch as are hard, falt, aluminous, and
the waters of lakes and marfhes. Pliny not
only diftinguifhes waters into nitrous, alu-
minous, bituminous, falt, fulphurated, aci-
dulous, chalybeate, falubrious, poifonous,
medicated, cold, warm, hot, fuch as boil
pulfe flowly, fuch as incruft the veffels in
which they are boiled, fuch as intoxicate,
fuch as change the colour of cattle, &c. but
mentions water boiled and cooled again by
fnow, according to Nero's method ; and af-
ferts, that vitiated waters are reftored by be-
ing boiled to one half (b).

But as to the art of accurately examining
waters, with regard to their contents, we
fcarce find any traces of it worthy of ob-
fervation, until the feventeenth century.
Tabernæmontanus, whofe true name was
(c) Jacob Theodore, about the end of the
fixteenth century, enumerates a variety of
the waters of Germany, and among the
reft Seltzer water, but he gives no analyfis

(a) Lib. de Aëre, Aquis & Locis.
(b) Hift. Nat. lib. xxxi. paffim.
(c) Wafferfchatz. Frankf. 1593.

of

of them. (*d*) Andrea Bacci, an Italian phy-
fician, whofe work was publifhed in the
year 1596, makes not the leaft mention of
analyfes of this kind, although no one be-
fore him had written fo accurately upon the
fubject of waters.

The illuftrious Mr. Boyle, in the year
1663, had difcovered the ufe of feveral pre-
cipitants. It had been before known, in-
deed, that fyrup of violets was made red by
vitriolic acid, and by lemon-juice : but this
effect was attributed to fome peculiar qua-
lity in thefe two liquors. Mr. Boyle dif-
covered this to be a property common to all
acids ; and was alfo the firft who obferv-
ed the green colour occafioned by alkalis,
which he inftances in the juice of blue-bell.
He mentions the blue folution of copper in
volatile alkali ; he relates that the colour of
rofes is deftroyed by the fumes of fulphur,
but heightened by its acid ; that water
tinged by Brazil wood grows yellow on the
addition of an acid, while that tinged by
cochineal has its red colour made more di-
lute ; and that alkalis reftore the original
intenfity of colour ; that filver is precipi-
tated from nitrous acid by fixed alkali, by
common falt, and by marine as well as vi-
triolic acid, but not by volatile alkali ; that
falited filver grows black in the open air ;
that vitriol of mercury grows yellow, when

(*d*) Septem de Thermis Libri. Rom. 1596.

wafhed with water ; that mercury diffolved
in acids yields a white precipitate, on the
addition of volatile alkali, but with fixed al-
kali a fediment of an orange colour, which
colour, on the addition of vitriolic acid, im-
mediately difappears, as does afterwards the
whole of the precipitate ; and that filver is
as it were gilded in folutions of a fulphureous
nature ; together with feveral other circum-
ftances, many of which had doubtlefs been
difcovered (e) before.   Thus, to pafs over
other inftances, Gaffendi fays, that tinc-
ture of rofes has its colour heightened by
vitriolic acid.

   Nearly about the fame time Dominic du
Clos, at the firft inftitution of the Royal
Academy of Sciences at Paris, in the year
1667, attempted to examine all the waters
of France, and continued his inveftigation
for fome years.   He made ufe of feveral
precipitants befides thofe above-mentioned,
fuch as infufion or powder of galls, and juice
of the flowers of leffer iris, to which he
afterwards added martial vitriol, and juice of
turnfole.   He examined the refiduum after
diftillation, inveftigated its figure by the
microfcope, its flavour, its folubility in wa-
ter, and put its properties to the teft of hot
iron.

   So long fince as the year 1680, fome re-
markable experiments upon this fubject

   (e) Experiments touching Colours. Oxon. 1663.

                                        made

made by Urbanus Hierne, were publiſhed in
Sweden. This very expert chymiſt makes
three claſſes of acidulous waters; namely,
the acid, the vinous, and ſuch as contain a
latent acid; he affirms that each of them
contains a peculiar ore, moſtly martial, to-
gether with a ſmall portion of ſulphur,
either manifeſt, as in the acid gas of Spa,
Pyrmont, and other waters of that nature;
or occult, being diſſolved by a concealed al-
kali; or as yet in a naſcent ſtate. He con-
ſiders the examination of the reſiduum as of
little conſequence, on account of the loſs of
the volatile particles; and thinks weighing
uſeleſs, imagining that volatile ſpirits do
not gravitate. He thinks that the tinging
linen will detect waters ſaturated with a
mature ore, but will not diſcover acidulous
waters: he denies that the goodneſs of me-
dicated waters can be determined by infu-
ſion of galls alone, inaſmuch as all waters
containing a groſs vitriolic ſalt ſtrike a black
with that infuſion, while various acidulous
waters of a more ſubtile nature, are not af-
fected by it; nor does he think the ting-
ing of raw fleſh ſufficient, as all vitriolic
waters induce on it the very ſame colour (f).
    In the year 1678, Hierne examined the
acidulous (g) Medway waters, which had

(f) Lilla Vattu-Profvaren. h. e. brevis Aquarum explo-
rator.   Stockh. 1683.
    (g) De acidul. Medviens. 1680.

3   been

been difcovered the year before, and foon after this fpecies of water came into general ufe in (*i*) Sweden.

Mr. Boyle again, in the year 1685, pro-pofed a number of fubftances for the more accurate examination of waters. He extols very much the volatile hepar fulphuris, dif-tilled from fixed alkali, fulphur, and fal am-moniac; this inftantly grows black, either with green or blue vitriol; hence he thinks that concealed fulphur may be difcovered by vitriol; he obferved that folution of arfenic grows black, and is precipitated by vitriol; he alfo affirms that he was acquainted with a method of difcovering common falt in water, without any evaporation, but he does not defcribe the method (*k*). He can fcarcely, in this cafe, allude to folution of filver, as, though known before, it was then but little ufed, but afterwards began to be more frequently employed; for in the year 1697 it was applied to this purpofe by Nic. Valerius, a Swede, who in his travels examined the hot waters of Aix; and, be-fides the above-named fubftances, employed folutions of nitre, common falt, fal ammo-niac, and faccharum faturni, the acids of

(*i*) Hiilphers de Font. foteriis Sueciæ.
(*k*) Apparatus brevis ad naturalem & experimentalem Aquarum Mineralium Hiftoriam, concinnatus in forma Epiftolæ, Lond. 1685.

nitre

nitre and fea-falt, and fpirit of fal ammo-
niac (*k*).

About the beginning of the prefent cen-
tury other fubftances began to be ufed : in
the year 1699, D. Regis and Didier em-
ployed tincture of mallow-flowers, which
is made red by acids, and green by alkalis
(*l*).   At the fame time Boulduc introduced
lime-water, and vinegar of lead.   Some per-
fon fent to Aix by Burlet mentions with
aftonifhment a filver cup, which having
been kept for three days in the Bath water,
became as it were gilded, a phænomenon
long before known to Boyle, and by him
afcribed to fulphur : it was afterwards ac-
counted for upon the fame principle, by
Homberg (*m*).

In the year 1707, Burlet availed himfelf
of folution of alum, paper tinged blue by
turnfole, the fame paper afterwards red-
dened by vitriolic acid, diftilled vinegar,
tincture of damafk rofes extracted without
acid, together with fome other fubftances.
In the fame year too, Geoffroi fubftituted
broad open glafs veffels to the clofe retorts,
which had been ufed until that time.

Befides, in 1726 and 1729, Boulduc em-
ployed various other contrivances.   For in-

(*k*) Tentam. Phyfico Chim. circa Aquas Thermal,
Lugd. Batav. 1699.
(*l*) L'Hiftoire de l'Acad. des Scien. de Paris, 1699.
(*m*) Ibid. 1707.

H   ftance,

ftance, until that time evaporation had been continued to drynefs, and the faline part of the contents again diffolved ; but Boulduc thought it more expeditious either to feparate the ftrata of the whole refiduum, or to feparate the different fubftances, in order as they prefented themfelves during the evaporation. He alfo fhewed the method of difcovering, by precipitation with highly-rectified fpirit of wine, the falts contained in any water, without expofing it to heat (*n*).

From hence it appears, that the principal precipitants at prefent known were in ufe at leaft from the middle of the feventeenth century ; but if we examine the conclufions deduced from the obfervation of their effects, we fhall be forced to acknowledge that they have been frequently unfatisfactory, and often more or lefs falfe.

It would be tirefome and ufelefs to relate the opinions of the antients concerning the heterogeneous matters found in water. Theophraftus Paracelfus was of opinion, that all the fpecies of earths with which he was acquainted, together with falts, bitumens, and certain metals, might be fufpended and carried about by that fluid : but, laying afide thefe unproductive fpeculations, we fhall proceed to a period more advantageous to natural philofophy. It has been already obferved, that alum was long fuppofed

(*n*) Mem. de l'Acad. de Paris, 1726 and 1729.

to

to be prefent in waters; nay, D. Giure, in the year 1669, contended that the peculiar nature of acidulous water was not conftituted by vitriol, but by alum, and a certain vein of foft iron, or, as he calls it, the ens primum of that metal. This, fo far as regards the alum, was however foon contradicted by Du Clos.—At prefent, alum is very rarely found in natural waters.

Du Clos at the fame time fpeaks of a certain falt, fimilar to gypfum; but Mr. Allen (o) was perhaps the firft who obferved in waters a falt confifting of vitriolic acid and lime, and which he calls felenite. By the word *nitre* nothing more was formerly underftood, than natron, or mineral alkali, which Hierne firft obferved in the acidulous waters of Egra (p), and F. Hoffman afterwards difcovered in feveral medicated fprings (q). The nature of this fubftance was accurately explained by Boulduc, in the year 1729.

The fal catharticus amarus, or more properly, vitriolated magnefia, has been in high efteem at Epfom, from the year 1610; and in 1696 Dr. Grew publifhed a fmall treatife upon that fubject; but, although it was found in the waters of Seidlitz, Seidfchutz,

(o) Nat. Hift. of Min. Waters of Great Britain, Lond. 1711.
(p) Brevis Aquarum Explorator.
(q) Opera, tom. v.

H 2   and

and at feveral other places, and was con-
fumed in great quantity, yet the true com-
pofition of it remained unknown until the
year 1755, when the celebrated Dr. Black (*s*)
undertook the accurate examination of the
nature of magnefia, the prefence of which,
even united with fixed air alone, was after-
wards difcovered in feveral waters (*t*).
Glauber's falt is found in many fprings,
and is often confounded with vitriolated
magnefia.   About the end of the feven-
teenth century a new method of detecting
common falt was difcovered, although its
tafte, and the form of its cryftals, had been
before that time generally confidered fuffi-
cient for the purpofe.

In the year 1682 Lifter difcovered lime in
waters; and in 1752 Le Roy found falited
lime in the laft lixivium (*v*).—Mar-
graaf difcovered falited magnefia in 1759 (*u*);
and F. Home nitrated lime in 1756 (*x*). As
vitriolated water ftrikes a black colour with
galls, and as moft acidulous waters poffefs
that property, it was immediately fuppofed
that fuch waters contain a vitriol: Theo-
phraftus Paracelfus (*y*) imagined he had put
that matter beyond doubt; but others who,

(*s*) Edin. Acts, tom. ii.
(*t*) Acta Stockh. 1773.
(*v*) Mem. de l'Acad. de Paris.
(*u*) Mem. de l'Acad. de Berlin.
(*x*) Experiments on Bleaching. Edin. 1756.
(*y*) De Thermis.

by

by evaporation, in vain attempted to obtain cryftals of vitriol, began to entertain doubt of the fact, yet by different ways endeavoured to get rid of the difficulty :—Some alledged that thefe waters contained neither iron nor vitriol, but a foft ore, or as they called it, an ens primum of that metal—— others had recourfe to a volatile vitriol, &c.

In the beginning of this century F. Hoffman attempted to eftablifh a new theory of mineral waters, denying that there was in the acidulous waters any true and actual acid ; he grants indeed, that an acid vapour does exift, which, together with a certain elaftic etherial principle, which he calls fpiritus mundi, conftitutes the fpirit and life of the medicated waters ; but he confiders this as volatile, and therefore eafily diffipated. On the contrary, he infifts that the acidulous waters are alkaline, becaufe they effervefce with acids, and change the colour of fyrup of violets to a green; thefe are marks, however, which we know to be ambiguous (§ VII.). As we are not acquainted with any alkali but fuch as has paffed through fire, and as alkalis are confequently confidered as the products of fire, many perfons denied the poffibility of their exiftence in waters (z). Hoffman himfelf thinks that the alkali originates from a fpirit of fulphur,

(z) Opera, tom. v.

which,

which, according to the degree of its fub-
tlety, would form with lime an alkalis
either fixed or volatile ;—Henckel thinks
the alkali derived from common falt, though
he owns he is ignorant how its acid can be
expelled.

At length Dr. Seip (a) gave an explana-
tion, which was thought to remove all the
difficulties compleatly ; he, with many of
the ancients, fuppofes that the genuine mi-
neral fpirit is the volatile vitriolic acid ; but
as the ancients (from the fudden change
which the water undergoes on expofure to
air) concluded that this volatile fubftance
flew off, he, on the other hand, contends
that the fubtile acid which had formerly
been united with iron, now forfakes the me-
tal to unite with the alkali, which in the
fubterraneous caverns could not exert its
fuperior attractive power ; and hence it is that
the remarkable change which acidulous wa-
ters undergo when expofed to the air, takes
place : this fpirit, he thinks, may be again
expelled by diftillation, and then obtained in
its proper form.   How far this explanation
is agreeable to truth, will be feen (§ VIII.)

In the year 1748 Dr. Springsfield (b) de-
livered it as his opinion, that air was the ef-
fective caufe by which the contents of the

(a) Befchreibung der Pyrmontifchers Mineral Waffer,
1771.
(b) Iter Medicum ad Aquas Spadanas.

fubtile

subtile waters were kept in a state of perfect clear solution, because the departure of air always occasions a turbidness and precipitation; and this opinion was afterwards further confirmed; for, in the year 1755, Venel's Commentaries on Seltzer Water were published; in which, by very convincing arguments, he shews that the volatile sulphureous acid is not the true mineral spirit, which on the contrary he contends is no other than the air itself; and he demonstrates these propositions by arguments both analytical and synthetical (c); and, although he did not arrive at the truth altogether, it must yet be confessed that he came nearer to it than any one before his time: he also attempted to prepare Seltzer water artificially. It is to be lamented that this very acute chymist, who superintended the examination of the waters in France, did not publish any thing more upon that subject before his death.

It is at length shewn, by incontrovertible experiments, that the genuine mineral spirit, which gives character and life to the cold mineral waters, is altogether the same with that fluid which is now called fixed air: this principle is common to the Seltzer, Spa, and Pyrmont waters; but different salts, in different proportions, determine the different species of these waters.

(c) Mem. der Sc. Etr.

H 4

Hence

Hence water, by bare impregnation with fixed air, cannot properly be called either Seltzer, Spa, or Pyrmont; nor can he be faid to underftand the artificial preparation of thefe waters, who merely knows the method of faturating water with fixed air.— The particular quantity of the different falts which conftitute the peculiar nature of each, muft alfo be known.—The vapour which is found in hot baths confifts fometimes of the aerial acid, as in the Caroline waters of Bohemia, but is frequently of a different nature, as we fhall fee hereafter.

In the year 1771, at Upfal, feveral perfons made ufe of waters artificially prepared, which exactly refembled the natural waters of Seltzer, Spa, and Pyrmont, not only as to the volatile part, but as to the entire contents (d); and the ufe of thefe waters afterwards obtained through moft of the provinces of Sweden.

In the year 1772 Dr. Prieftly publifhed a book at London, in which he taught how water might be faturated with the fixed air expelled from chalk by vitriolic acid. — Mr. Lane had before employed fermentation for the fame purpofe, with the addition of iron, by which the water became a chalybeate.

(d) Vet. Acad. Handl. 1773.

The

The hepatic vapour, with which many hot baths are impregnated, has occasioned much perplexity, because sulphur cannot artificially be obtained from them, though it sublimes spontaneously, as at Aix.—Of those who have laboured in this field it is sufficient to name Charles Lucas, who yet did not succeed (e). At present the mystery is unfolded (§ IV. VII. F. VIII. E.)

Finally, I should mention, that the knowledge of the heterogeneous matters contained in waters, lately acquired, has excited many to undertake a classification of waters, according to their contents. On this principle the celebrated Professor Sir J. G. Wallerius, published, in the year 1748, his Systema Hydrologicum (f).—F. A. Cartheufer, in 1758 (g), published a work of the same kind; as did also Mr. Monnet, in 1772 (h); not to mention those who, limiting their researches to the waters of certain countries, have not treated the subject at large.

The nature of the present Work does not permit me to spend any time in relating the several discoveries of the moderns, which have led the way to a compleat examination of waters; besides, these are all to be found

(e) Essay on Waters. Lond. 1756.
(f) Wattu-Riket. ad Fin. comparet brevis Introd. ad Aquas examinand.
(g) Rudimenta Hydrol. Syst. Fr. ad. V. 1758.
(h) Nouv. Hydrologie, 1772.

in the modern books. Let the candid and
fkilful judge whether the demonftration of
the acid nature of fixed air, the folution of
chalk and magnefia in water, by means of
that fubtile menftruum, and the analyfis and
fynthefis of Seidfchutz, Seltzer, Spa, and
Pyrmont waters, have contributed any thing
to that purpofe.

§ 11. *The Examination of Waters highly ne-
cefary.*

Water, confidered by itfelf, and free from
any heterogeneous mixture, is, as far as con-
jecture can reach, always of the fame na-
ture ; but, during its paffing over or pene-
trating various ftrata, it is loaded with he-
terogeneous matter, more or lefs, according
to circumftances; very fubtile powders being
partly mechanically fufpended in it, and
partly united intimately with it, in the way
of chymical folution : hence no water is
ever found upon the furface of the earth in
a ftate of perfect purity ; nay, even rain and
fnow-water, although elaborated by the pe-
culiar powers of nature from the moft fub-
tile vapours, with a degree of perfection in-
imitable by art, thefe, I fay, though col-
lected with all poffible care, are yet found
varioufly contaminated, according to the
feafons of the year, the climate, and other
circumftances.

The

The heterogeneous particles which waters contain differ with refpect both to quality and quantity ; hence it is that fome are fit for the ufes of life, others unfit, noxious, or even fometimes mortal ; while others are found extremely efficacious in curing, or at leaft in alleviating diftempers. The medicinal waters differ very much in power, according to the quantity and quality of the particles contained in them ; hence fome which experience fhews to have been employed with the beft fuccefs in certain cafes, in others may prove either inert or noxious. In the brewing of malt liquors, the baking of bread, the boiling of pulfe, the wafhing and bleaching of linen, the dying of different fubftances, the preparing of hides, fkins, and paper, and in a number of other arts, the quality of the water employed is of fo much confequence, that, unlefs one be chofen fit for the purpofe, the whole procefs fails.—Water is ufed in confiderable quantity in the preparation of food, and always conftitutes the greater part of our drink ; infomuch that if we allow one kanne per diem to each adult, our calculation will rather fall fhort, than exceed.

Hence it readily appears how a quantity of pernicious heterogeneous matter, though fmall, being daily accumulating, may foon lay the foundation of numberlefs difeafes.

From what has been faid, I believe it is fufficiently obvious, that the analyfis of wa-

ters is highly neceffary, not only as a fpe-
culative branch of natural philofophy, but
as fubfervient both to public and private ad-
vantage.—From thence we are enabled,

1ft, To chufe the pureft water for inter-
nal ufe.

2d, To avoid fuch as is either unfit or
noxious.

3d, To form a proper judgment con-
cerning fuch as are ufeful in medicine.
Thus, if long experience has fhewn
the efficacy of the water in a certain
fountain, and if at the fame time the
contents of that water be known, we
are enabled to anticipate the experience
of years, and inftantly to form a judg-
ment concerning the virtue of other
waters, which exactly refemble in
their contents the water whofe proper-
ties are already eftablifhed.

4th, To felect fuch waters as are beft
adapted to the feveral arts and manu-
factures.

5th, To amend the impure (in fcarcity
of good water) and to feparate from it
thofe heterogeneous particles which
chiefly impede its ufe.

6th, To imitate fuch as are celebrated
for extraordinary virtues, if a fufficient
quantity of the natural water cannot
conveniently be had.

§ III. *An*

§ III. *An accurate Analyſis of Waters is juſtly conſidered as one of the moſt difficult Problems in Chymiſtry.*

In proportion as an ingredient forms a ſmaller part of a compound ſubſtance, the more difficult it is to diſcover that ingredient, becauſe it is the more inveloped and hidden.—By means of fire we ſometimes diſcover $\frac{1}{12000}$ part, and even ſometimes a ſmaller proportion;—but in the analyſis of waters it is often neceſſary to detect $\frac{1}{50000}$, nay $\frac{1}{100000}$.

When the ſubſtance contained is not only ſmall, but alſo compoſed of different ingredients, the ſeparation becomes ſtill more difficult. Sometimes the heterogeneous matters in water amount only to $\frac{1}{6000}$, yet this is found to be compoſed of ſix, ſeven, or eight different ingredients, mixed together in ſuch a manner as to be eaſily confounded; it is, notwithſtanding, neceſſary to determine the quantity and quality of each.

Add to this, that ſome of the contents are ſo ſubtile as to elude the ſenſes, or ſo volatile as to fly off imperceptibly; ſome of the principles alſo are decompoſed during the examination—hence they require to be inveſtigated by peculiar contrivances.

It may be thought that the difference of a few grains in a kanne will not eſſentially
tially

tially alter the peculiar virtue of the water; but experience ſhews the contrary very clearly.

Theſe circumſtances will ſerve to ſhew the difficulty of the queſtion before us, even to thoſe who are altogether ignorant of chymiſtry.——And perſons who are even more than moderately ſkilled in that ſcience, muſt exerciſe peculiar addreſs, in order to perform the neceſſary operations with ſufficient accuracy. We can by no means therefore imagine, that powder of galls and ſyrup of violets are altogether ſufficient for this purpoſe.

I ſhould now proceed to deſcribe the method which I found moſt convenient in conducting this proceſs; but it will be advantageous, previouſly to know what heterogeneous ſubſtances are uſually found in cold waters.

§ IV. *What heterogeneous Matters are generally found in Waters.*

Very minute particles of flint, lime, magneſia, and clay, are ſometimes found mechanically ſuſpended in water. The argillaceous particles obſcure its tranſparency, and render it of an opal colour; the others occaſion variations which are leſs obſervable, becauſe the ſubtilty of their particles and the ſurrounding water render them tranſparent.——All theſe ſubſtances, when
ſufficiently

sufficiently comminuted, acquire a surface so large, in proportion to their weight, that the friction necessary to be overcome in their descent becomes superior, or at least equal, to the difference of specific gravity between the particles of the earth and those of the water, which is the force with which the earthy particles tend to the bottom; and so long as this equilibrium takes place, the particles, once diffused in the water, will remain suspended.

But various substances are found united with water, and with each other, much more intimately, that is, by means of chymical solution—these are now to be enumerated, and to each we shall subjoin a reference indicating the place, in the following pages, where the specific nature and quantity of each of them are particularly treated of.

Pure air is contained in most waters, in the proportion of about one cubic inch to a kanne; this, when expelled by boiling, or by the air-pump, is gradually recovered from the atmosphere (VII. S; VIII. A, B.)

Aerial acid also is found in every water, but in very unequal quantity, from $\frac{1}{100}$ of the bulk of the water, to a bulk equal to that of the water itself. This, as well as the pure air, by its dilatation under the receiver, produces a number of bubbles;—it communicates to water an agreeable, pungent, and

refrigerant

refrigerant flavour (VI. A, B, C; VII. A, F, K, S; VIII. A, B, C, D.)

Inflammable air sometimes issues from waters; this species of air, however, is not united with the water, but rises from the bottom, and is expanded at the surface.

The other acids, in a disengaged state, are only found in waters accidentally (VI. C; VII. A, H; VIII. D.)

Vegetable alkali is rarely found in waters, and almost always in combination (VI. C; VII. B, C.); sometimes vitriolated or salited, but more frequently nitrated (XI. B, 1, 2, 3.)

Mineral alkali, however, often occurs, either aerated, vitriolated, or salited (VII. F; XI. B, 1, 2, 3.)

Volatile alkali is sometimes present, probably communicated by putrid vegetable or animal substances (VI. B, C; VII. B, C; VIII. F.)

Terra ponderosa is sometimes accidentally found united with marine acid (VII. F, L; X. D, 6; XI. B, 4.)

Lime frequently occurs aerated, vitriolated, nitrated, or salited (VII. G; X. D; XI. A, C.)

Magnesia is not so frequently found; yet sometimes it occurs either aerated, vitriolated, nitrated, or salited (X. D; XI. A, B, 4.)

Vitriolated clay (*i*), or alum, is rarely found in waters (VI. C; VII. N; X. D; XI. B, 4.)

Among the metals *iron* is moſt frequently diſcovered in waters, and that, aerated, (VI. F; VII. D, E; X. D, 4.) vitriolated, or ſometimes perhaps ſalited (XI. B, 5.)

Manganeſe has not yet been found, except ſalited, although it may poſſibly be diſcovered aerated or vitriolated (VI. F; X. D, 4; XI. B, 5.)

Copper has only been found vitriolated (VI. A, F; XI. B, 5.)

Arſenic very rarely, and in the form of a calx (XI. B, 5.)

Extracts from vegetable and animal ſub-ſtances, with which water, paſſing through ſtrata containing ſuch bodies, is ſometimes contaminated.

Somewhat of *an hepatic* nature is alſo found, eſpecially in hot waters, and ſometimes alſo in cold chalybeate waters ; but in general it is ſo ſubtile that it inſtantly flies off in the open air, and manifeſts itſelf no other way than by its ſmell (VI. B.). A genuine hepar is rarely preſent, although it is fallaciouſly indicated by an hepatic vapour, confiſting of ſulphur reſolved into the form of vapour by means of phlogiſton and the

(*i*) An ingenious Engliſh phyſician has detected an earthy ſalt, which one ſhould ſtill leſs expect to find in water. He has met with muriated or ſalited clay in Nevil Holt water, which has long baffled the attempts of chymiſts to analyſe it.—His analyſis has not been publiſhed. B.

matter

matter of heat; as is clearly demonſtrated in the Treatiſe on the products of ſubterraneous fire. The method of ſeparating the ſulphur in its proper form will be explained, (VII. F, T.)

I could not diſcover any certain ſigns of *bituminous oil*, it being immiſcible with water, unleſs by means of an alkali. Petroleum, agitated with diſtilled water, ſeparates again upon ſtanding. It muſt be acknowledged, however, that the water, even after the moſt careful filtration, ſtill retains a ſtrong bituminous ſmell; yet nitrated mercury occaſions no precipitate (VII. P.)

Theſe heterogeneous matters are never found all together, but are more or leſs numerous in different waters. Thus ſome of them are contained in atmoſpheric waters; others in thoſe found on the ſurface of the earth; and, finally, others in ſea-water.

Snow-water contains a ſmall quantity of ſalited lime, together with ſome ſlight veſtiges of nitrous acid; this water, when newly melted, is totally void both of air and of the aerial acid; ſubſtances which are found, in greater or leſs quantity, in almoſt all other waters :—and hence it is, perhaps, that ſnow-water is noxious to animals.

Rain-water is generally contaminated with the ſame ſubſtances as the former, but in greater quantity: it is obvious that theſe waters, while ſuſpended in the air, muſt collect and abſorb the various heterogeneous

matters

matters with which the atmofphere abounds, and therefore can never be obtained pure. Immediately after long-continued rain or fnow, thefe waters are found leaft loaded with heterogeneous matter.

Spring-water, when of the pureft kind, contains but little heterogeneous matter, otherwife we find in it aerated lime, falited lime, common falt, and fometimes a fmall quantity of alkali.——Thofe fprings which are called mineral alfo contain gypfum, aerated and vitriolated magnefia, vitriol, aerated iron, &c.

River-waters are often fo much purified by their motion as to contain nothing more than aerated lime, common falt, and fometimes a little alkali. Thefe are generally lighter than fpring-waters, and the more pure, in proportion to the rapidity of their courfe, and the hardnefs of the bottom over which they run.

Well-waters, befides a large quantity of the above-mentioned fubftances, often afford gypfum and nitre.

Lake-waters are lefs clear than any of the former, they are alfo heavier, and depofit fpontaneoufly fome earthy fediment: they fometimes contain all the fubftances above recited; and befides, are generally vitiated by an animal or vegetable extract.

Marfh-waters have lefs motion, and therefore are lefs clear, more heavy, and more vitiated by extractive matter; hence they generally

I 2

nerally

nerally exhibit fomewhat of a yellowifh
brown colour.

Sea-water contains common falt, vitrio-
lated and falited magnefia, gypfum, and a
confiderable quantity of the putrid extract,
which is generated partly from the innu-
merable crowd of animals which there live,
die, and are decompofed ; and partly is there
collected by falling into it from the earth.

In examining the products of fubterrane-
ous fire, I have particularly enquired whence
thefe heterogeneous matters, and the diffe-
rent degrees of heat in waters, are derived.

§ v. *Water may be examined in two different
ways, by Precipitants, or by Evaporation.*

We attain the knowledge of the hete-
rogeneous matters in water chiefly by two
methods, by precipitants, and by evapora-
tion. Precipitants are fubftances which,
on being added to waters, either immediate-
ly, or after fome fhort time, by altering
their colour or difturbing their tranfpa-
rency, fhew the heterogeneous matters they
contain. Thefe, for the purpofe of expedi-
tion, are very commodious, but they do not
afford an accurate decifion, efpecially when
the queftion is concerning quantity.   The
weight of the precipitate may often, indeed,
be of confiderable ufe even in that view, as
fhall prefently be fhewn, though it has not
yet been employed for that purpofe.

The

The other method confifts in feparating the contents by evaporation and cryftallization.

When there is time fufficient, and we wifh to examine a water very accurately, both thefe methods fhould be employed, as they reflect mutual light upon each other, and the precipitants indicate the proper method of conducting the evaporation.

Finally, in order to form a right judgment, we muft confirm our analyfis by fynthefis. For this purpofe the pureft fnowwater, gently diftilled, and freed from empyreuma by ftanding in the open air, fhould be employed; and when the heterogeneous matters which have been difcovered are added in due proportion, the artificial water fhould be precifely like the natural in every circumftance.

§ VI. *The Phyfical Qualities to be obferved.*

In forming a judgment of the nature of waters, their fenfible qualities afford no inconfiderable affiftance.

(A) The fight is capable of afcertaining many circumftances of confequence.

A *clearnefs* equal to that of cryftal indicates great purity. On the contrary, muddinefs, and a brown colour fhew plainly that heterogeneous matters are fo grofsly mixed with the water as to obftruct the paffage of the rays of light. When the bottom is clay

I 3

or mud, the water is never perfectly clear ; but when it runs over fand it is in general extremely tranfparent.

Good water is entirely without colour, but it does not thence follow that all colour-lefs water is to be confidered as good. A brown colour, verging to red or yellow, is found in dull ftagnant waters ; it is fome-times occafioned by iron, fometimes by pu-trid extractive matter, and fometimes, per-haps, is derived from fome unctuous fub-ftance.—A blue colour indicates vitriol of copper ; a green, martial vitriol, &c.

If the water, upon agitation, emits a num-ber of airy bubbles, a quantity of aerial acid is indicated.

(B) Good water has no *fmell*. — Such as abounds with the aerial acid diffufes a fubtile and penetrating odour ; fuch as con-tains any portion of hepar fulphuris yields a fmell refembling that of putrid eggs or fired gun-powder.—Stagnant and corrupted waters have a putrid offenfive fmell.

(c) Water is the better, in proportion as it is the more compleatly void of tafte ; yet a palate which is delicate, and accuftomed to the tafte of waters, will difcover fome difference even among the pureft.—Aerial acid occafions a gently pungent acefcent tafte ;— a bitternefs accompanies Glauber's falt, nitre, vitriolated, nitrated, or falited magnefia ; as alfo nitrated or falited lime ; —a flight aufterity proceeds from lime or gypfum

gypſum — a ſweet aſtringency from alum
—a ſaltiſhneſs from common ſalt— a lixi-
vious flavour from alkali—an æruginous one
from copper—and an inky one from iron.

(D) The ſpecific gravity lays in ſome de-
gree a foundation for eſtimating the quan-
tity of heterogeneous matters contained in
water; but cannot always determine the
matter with accuracy, becauſe, in ſome in-
ſtances at leaſt, a mutual penetration may
take place.

It is, however, in general true, that the
lighter waters are more pure than the
heavier ; and for determining this point
an hydroſtatic balance, and a good aerome-
ter, are peculiarly convenient : but if theſe
inſtruments are not to be had, an ordinary
balance may be ſo managed as to compare
the weight of diſtilled, or very pure ſnow-
water, with that of other waters ; this is
done by means of a glaſs veſſel with a nar-
row neck, which is to be filled with water
to a certain mark, and exactly weighed.
The larger this veſſel is the better — but
one containing a quadrans (*k*) or two, is
generally ſufficient ; for greater quantities
require large weights, which are leſs accu-
rate.

Finally, in whatever way theſe experi-
ments are made, the waters compared muſt

(*k*) The Kanne contains 8 quadrantes, of which each
contains 12½ Swediſh inches.

be

be of the fame temperature, otherwife the conclufion will neceffarily be fallacious.

(E) In the examination of waters, the temperature fhould be determined by an accurate thermometer, and the following particulars obferved :—whether the temperature of the water under examination is the fame throughout the year ; or whether it follows the changes of the atmofphere — whether it freezes in winter—whether the hot waters form any depofition during refrigeration— and whether, in confequence of cooling, their fmell and tafte grow faint, or entirely difappear.

(F) Local circumftances are by no means to be neglected ; to thefe belong the fituation of the water, with refpect to its geography both political and natural, and the elevation and properties of the furrounding foil. The quantity of the water fhould alfo be obferved—whether it remains the fame at all feafons of the year, or is obvioufly dependent upon dry weather and rain — whether it is ftagnant—whether it runs fwiftly or flowly—what quantity flows from the fpring in a given fpace of time—how many veins the fpring confifts of, &c.

Whether the water depofits in its bed a faline, an earthy, an æruginous, or an ochry fediment—whether bodies lying in it are covered with a cruft—whether faline efflorefcences are to be found in its neighbourhood—whether, in the channels and caverns

3   through

through which it passes, sulphur is sublimed —whether it issues gently, or bursts forth with a sort of ebullition, &c.

It is also proper to observe whether any vegetables grow in the water, and what— and whether any animalculæ live in it.

§ VII. *The principal Precipitants.*

(A) *Tincture of turnsole* is obtained from the pigment called lakmus, enclosed in a clean linen cloth, and steeped in distilled water. This water soon assumes a blue colour : but, when viewed against the light, it shews a violet tinge. If water be gradually added, the reddish tinge is diminished, and at last entirely disappears. This tincture is capable of detecting the most minute particle of disengaged acid, by instantly growing red. A single grain of highly concentrated vitriolic acid communicates a visible red tinge to 172,300 grains (*l*), or 408 cubic inches, of the blue tincture.

In these experiments the same glass vessel, or at least vessels nearly similar, should always be employed; for a small difference in the diameter of the containing vessel will occasion a difference in the colour of the tincture, when viewed with the rays of light passing through it : — The vessel which I make use of in these experiments is

(*l*) The Swedish apothecaries pound consists of 12 ounces, and each ounce of 480 grains.

cylindrical,

cylindrical, and 17 decimal (*m*) lines in diameter.

Paper tinged by faturated tincture of turn-fole, with a little ftarch boiled in it, is in certain cafes more readily changed ;—a paper thus prepared, dipped into diftilled water containing 12 grains of highly concentrated vitriolic acid to the kanne, and inftantly taken out, is found to be red—and this fame paper, after being made red by diftilled vinegar, ferves to difcover alkalis, by recovering its blue colour more or lefs compleatly. The prefence of an alkali may, to a certain degree, be difcovered by means of the blue paper—its blue colour being heightened by the alkali. Diftilled water, containing 40 grains of cryftallized fal fodæ to the kanne, reftores the blue colour to the paper reddened by vinegar, and a much lefs quantity of alkali renders the red colour obfcure.

We muft not, however, be without the tincture itfelf, as being more fenfible than the paper. Thus, water faturated with aerial acid, does not change the colour of the paper, yet one part of fuch water makes about 50 parts of the tincture diftinctly red ; nearly the fame effect is produced by a fingle grain of highly concentrated vitriolic acid, mixed with 3,445 grains

(*m*) The Swedifh foot confifts of 10 inches, and each inch of 10 lines.

of

of diftilled water; therefore, fuppofing the fpecific gravities of diftilled water, concentrated vitriolic acid, and aerial acid, to be, refpectively, as 1, 2, and 0,0018, we can in fome meafure compare the forces of thefe acids; for, upon calculation, they are found to be in equal weights, as 3,445 to 555, or as $6\frac{1}{5}$ to 1 —and in equal bulk as 6,890 to 1.

(B) *The watery tincture of Brazil wood* is red, but readily takes a blue colour from alkalis; paper fteeped in this tincture, with a little ftarch boiled in it, is alfo red, and is equally fit for the prefent purpofe; we may therefore difpenfe with the tincture, the application of which is more troublefome. One grain of newly cryftallized fal fodæ, diffolved in 4,295 grains of water, or (which is the fame) 10 grains in a kanne, changes the red colour of this paper to a blue, faint indeed, but eafily diftinguifhable; nay, an experienced eye will perceive the change, even though there be no more than fix grains to a kanne.

Acids induce a yellow colour upon paper tinged by Brazil wood, and reftore immediately the original red colour to the paper which has been made blue by alkalis.

(c) *Watery tincture of turmeric* is more or lefs changed to a brown by alkalis: paper tinged, as in the former cafe, by this tincture and ftarch, poffeffes the fame property with the foregoing; fo that the tincture may

be

be difpenfed with. A fingle grain of newly cryftallized fal fodæ, diffolved in 859 grains of diftilled water, communicates to it the property of manifeftly obfcuring the yellow colour of the paper : hence a kanne of water will not produce the fame effect, unlefs it contains 49 grains of that alkali—acids ren- der the yellow colour fomewhat paler—vo- latile alkali produces changes upon all thefe papers, but thefe changes are very fugitive.

All thefe precipitants may be advanta- geoufly employed; the firft, chiefly for difco- vering acids, and the two laft for alkalis ; it is true, indeed, that the blue of the turnfole, when changed to a red by acids, may ferve to difcover alkalis, fo that the papers tinged by turmeric and Brazil wood may feem un- neceffary ;—but we muft obferve that the latter of thefe two exceeds all other tefts in fenfibility, fo as even to difcover cer- tain earths diffolved in water by means of aerial acid, fuch as terra ponderofa, lime, and magnefia. As to the former, it is in- deed more flow, but by this very flownefs it indicates in fome degree the relative quan- tity ; and befides, when it is neceffary to obferve the change of colour occafioned by alkalis by candle-light, the effect upon tur- meric is more diftinguifhable.

Syrup of violets, therefore, is by no means neceffary, efpecially as, 1ft, we can feldom have any genuine, at leaft in Sweden ; 2d, this - fyrup fpontaneoufly acquires a red colour

colour by fermentation; and 3d, it is render-
ed green not only by alkalis, but by iron;
which renders any conclusion drawn from
thence ambiguous (*n*).

The general rule, namely, That blue ve-
getable juices are made red by acids, and
green by alkalis, is liable to two exceptions
already known; viz. lakmus is rendered
more intensely blue by alkalis, and indigo
dissolves in vitriolic acid, without any change
of colour. The blue juices of different ve-
getables are unequally affected by acids and
alkalis; a circumstance which demands a

(*n*) It may be doubted whether the reasons here alledg-
ed are sufficient to justify the learned Professor in expel-
ling so contemptuously syrup of violets from the place that
it has so long held in the class of reagents. For, 1st, we
are taught by chemical writers how to distinguish the ge-
nuine from the spurious syrup, viz. by solution of corro-
sive sublimate, which changes the former to a green, while
it reddens the latter. 2. It is not easy to be misled by
the alteration produced by the spontaneous fermentation,
because the experimenter cannot fail to perceive that be-
fore-hand. 3. He who has once compared the green pro-
duced by iron with that produced by alkalis, will easily
be enabled to distinguish them on every future occasion;
the latter being a lively and pleasant tinge, the former
a yellowish dirty hue. 4. " When certainty," says M.
de Morveau, " can only be attained by the coincidence of
many results, this additional instrument, which in some
cases shews properties different from other analogous
reagents, ought not to be entirely thrown aside."
" M. Neuman and the Count de Saluces," adds the
same judicious annotator, " have observed that syrup of
violets passes from green to yellow when the alteration
has been made by alkaline liquors, but continues green
when the change has been produced by neutral salts."
Mem. de Turin. B.

series

feries of experiments, in order to afcertain the relative power of thefe falts. Pure aerial acid does not exert its power, except upon tincture of turnfole; —diftilled vinegar changes fyrup of violets, but has no effect upon the blue paper ufed for covering fugar-loaves, which yet is made red by the ftronger acids; and fo of the reft.—Befides, determined weights of vitriolic acid and of alkali fhould be fucceffively mixed with different quantities of water, and their various effects upon the vegetable juices accurately noted. Thus, from a comparifon of their effects, the quantities of acids and alkalis, which are at prefent unknown, might in fome degree be determined. But this ufeful inveftigation requires a long train of experiments.

(D) *A faturated tincture*, extracted by fpirit of wine from powdered galls: the watery tincture may alfo be employed, but it foon grows mouldy.—By this tincture iron is difcovered, being flowly precipitated: —if the quantity of metal be fmall, the precipitate is purple; if large, black. Diftilled water, containing three grains of cryftallized martial vitriol in the kanne, upon the addition of a fingle drop of this tincture, grows diftinctly purple in lefs than five minutes. Yet three grains of martial vitriol contain no more than $\frac{1}{24}$ grain of iron.

(E) *The phlogifticated alkali*, as it is commonly called, is beft prepared from four

parts

parts of Pruſſian blue, boiled with one part of alkali in a ſufficient quantity of water. The clear liquor, ſaturated with an acid, muſt then be freed by filtration from the ſmall portion of Pruſſian blue which is ſeparated.—This preparation is extremely well adapted for diſcovering the ſmalleſt portion of iron. Diſtilled water, containing in the kanne one, or at moſt two grains of green vitriol, on the addition of a ſingle drop of this lixivium inſtantly ſhews a Pruſſian blue.—It alſo precipitates other metals;—copper it precipitates of a reddiſh brown colour—manganeſe, white; and ſo of the reſt.

(f) *Concentrated vitriolic acid* dropped in-water immediately precipitates a ſpathum ponderoſum, if (which rarely happens) there be preſent any terra ponderoſa (iv.) The appearance of a number of bubbles ſhews whether there be any conſiderable portion of alkaline ſalt, lime, or magneſia, diſſolved by the aerial acid. — In order to occaſion a ſenſible efferveſcence there ſhould be at leaſt 390 grains of newly cryſtallized ſal ſodæ in a kanne, a quantity which however is not affected by ſtrong marine acid. The other mineral acids may be employed for the ſame purpoſe; but the effects of theſe will be always leſs remarkable, as they are leſs ſuſceptible of concentration to ſo great a degree as the vitriolic acid.—The concentrated nitrous acid is however very uſeful for

for difcovering fulphur in the hot waters which have an hepatic fmell—for this acid, feizing the phlogifton, precipitates the fulphur which, by its means, was united to the matter of heat, though the fulphur fo combined is able to elude all the ordinary modes of examination;—concentrated nitrous acid, added in proper quantity, foon takes away the hepatic fmell, thereby indicating a decompofition, and the fulphur, fubtilely divided, falls flowly to the bottom.

(G) *The acid of fugar* is one of the moft delicate tefts hitherto known for the difcovery of lime, however mixed. A fingle grain of pure lime diffolved in a kanne of diftilled water, fhews white clouds and ftriæ, if a fmall portion of cryftallized acid of fugar be laid on the furface, or diffolved and dropped in.

If the lime be in a ftill fmaller quantity, and the moft minute cryftal of faccharine acid let fall to the bottom, in a fhort time a fort of powder, confifting of faccharated lime, is found about the fpot where the cryftal falls. Scarce any water is entirely free from lime; and the pureft, within 24 hours at leaft, depofits a portion of faccharated lime, although fometimes fo fparingly as to efcape obfervation, unlefs lines be drawn on the bottom of the veffel with a glafs rod. —Such is the water of Varby, which is juftly enumerated among the beft waters in Sweden.

Effential

Eſſential ſalt of wood-ſorrel, and the *micro-coſmic ſalt,* alſo precipitate lime; but more ſlowly and leſs effectually than the acid of ſugar does.

(h) *Aerated fixed alkali* precipitates all earths and metals from their ſolutions: if the ſubſtance to be precipitated is eaſily ſoluble in the aerial acid, the cauſtic alkali in general effects a more remarkable ſeparation—generally, I ſay, for this is not always the caſe; for terra ponderoſa is not precipitated by that alkali.—If there happens to be preſent a diſengaged mineral acid, every particle of the aerated alkali emits bubbles.

(i) *Aerated volatile alkali* precipitates all earths and metals; but cauſtic volatile alkali has no effect on lime or terra ponderoſa. Diſtilled water, containing 98 grains of vitriol of copper to the kanne, is ſcarcely blue. If in the ſame quantity of water there be only $6\frac{1}{2}$ grains, the copper is diſtinctly precipitated on poliſhed iron; but a few drops of ſolution of volatile alkali only occaſions a cloud, which is ſcarcely viſible. This cloud, if the vitriol be in larger quantity, ſoon changes from an aſh colour to a blue; and, when well diffuſed by agitation, communicates to the water a faint and duſky tinge. If the volatile alkali be ſuperabundant, all the precipitated copper is rediſſolved with a moſt beautiful azure colour; for the quantity of this metal which is contained in four grains of blue vitriol, is

ſufficient

sufficient to give a visible tinge to a whole kanne of water, if the copper be precipitated by a proper quantity of volatile alkali, and afterwards re-diffolved by a fuperabundance of the fame alkali.

(K) *Lime-water* dropped into water which contains any aerial acid, renders it inftantly turbid; becaufe that portion of the lime which is faturated by that fubtile acid lofes its folubility.

(L) *Salited terra ponderofa* is of confiderable ufe in difcovering the fmalleft veftige of vitriolic acid, with whatever menftruum it may be united; for this acid feparates terra ponderofa from all others, forming with it a fpathum ponderofum, fcarcely any of which water is able to take up. Diftilled water, containing 12 grains of newly cryftallized Glauber's falt to the kanne, on the addition of a few drops of folution of falited terra ponderofa, immediately exhibits white ftriæ.—If there be prefent no more than three grains of the Glauber's falt, after a few minutes a cloud forms at the bottom, which alfo happens even when there is but one grain in the kanne; but in this cafe the water muft ftand fome hours before the cloud becomes vifible. Now, that we may the better judge how great the nicety of this precipitant is, let us confider that 12 grains, 3 grains, and 1 grain, of Glauber's falt, contain refpectively no more than 3, 0,78, and 0,26 grains of vitriolic acid; fo that this fubftance:

fubftance exceeds turnfole itfelf in fenfi-
bility.

(M) *Salited lime* is generally confidered as
a ufeful medium for difcovering fixed alkali,
for the aerated lime feparates, and falls to the
bottom; but this experiment is ambigu-
ous, becaufe, if any vitriolated magnefia be
prefent, a double decompofition takes place,
and a gypfum is formed.

(N) *Solution of alum* has fometimes been
employed, but is of little ufe, as it is decom-
pofed by alkalis, either fixed or volatile,
and by aerated, falited, or nitrated lime.   If
a piece of alum, the bulk of a fmall pea, be
put into the water under examination, in a
quarter of an hour a fpungy ftratum is
obferved, horizontally fufpended near the
bottom : however, as before obferved, the
caufe of this phænomenon is uncertain, un-
lefs determined by other experiments.

Seven grains of alum diffolved in a kanne
of water, upon the addition of a fingle drop
of folution of alkali, either mild or cauftic,
inftantly fhew a manifeft argillaceous pre-
cipitate.

(O) *Nitrated filver* diffolved in diftilled wa-
ter affords a moft compleat method of difco-
vering the fmalleft traces of marine acid;
for this acid, whether difengaged or united
with another bafe, inftantly feizes the filver,
forming with it a metallic falt very diffi-
cult of folution, which therefore feparates
in the form of a white mucilage.   A fingle

grain

grain of common falt diffolved in a kanne
of diftilled water, at the firft drop of folu-
tion of filver exhibits white ftriæ, which,
however, are not produced, if the water con-
tains no more than half a grain—but a grain
of common falt contains about half a grain
of marine acid.—Solution of filver is acted
upon by vitriolic acid far more flowly, for
no vifible turbidnefs will arife, unlefs the
kanne of water contains 98 grains of Glau-
ber's falt, which contain 25 grains of vitri-
olic acid. Now, fince the acid conftitutes
one fourth of falited filver, we may deter-
mine the quantity of marine acid from the
weight of the precipitate effected by the fo-
lution of filver when the precipitation is
compleat.—The quantity of acid contained
in vitriolated filver is very little greater.

If any hepar be prefent, the falited filver
which precipitates is of a lighter or darker
brown colour. It is alfo proper to obferve,
that a fingle drop of folution of filver occa-
fions a vifible precipitation in water alto-
gether deftitute of both marine and vitriolic
acid, provided it contains 12 grains of newly
cryftallized fal fodæ to the kanne. Lime
and magnefia, united with aerial acid, in
like manner precipitate filver : but the
quantities have not yet been exactly deter-
mined.

(p) *Nitrated mercury* is to be employed
with great circumfpection, as it poffeffes
different properties, according to the cir-
<div align="right">cumftances</div>

cumſtances of the ſolution; for if the ſo-
lution has been conducted without heat,
very little phlogiſton is loſt, and the ſalt
eaſily cryſtallizes, being white, and ſcarcely
acrid.   This is precipitated, by cauſtic ve-
getable alkali, of a yellowiſh white : by the
ſame alkali, ſaturated with aerial acid, white:
by ſal ſodæ, yellow, which ſoon grows
white : by volatile alkali, greyiſh black :
by Glauber's ſalt, or diſengaged vitriolic
acid, white, granulated, and in ſmall quan-
tity ; nor, if the precipitant has been ſpar-
ingly uſed, does it appear in leſs than an
hour : by marine acid, common ſalt, and
other ſaline ſubſtances containing that acid,
white, in large quantity, and of a caſeous
conſiſtence.   Solution of mercury, made
without heat, immediately diſcovers the ma-
rine acid, even although there be no more
than half a grain of common ſalt in a kanne
of diſtilled water : but it diſcovers vitriolic
acid more ſlowly ; for about four grains of
Glauber's ſalt, (that is, one grain of acid)
are requiſite in a kanne of water, in order to
occaſion a viſible precipitation with the
ſame degree of quickneſs.

When neither vitriolic acid nor marine
acid is preſent, the mercury is precipitated
by alkalis ; as alſo by lime or magneſia
diſſolved by means of aerial acid. — A
ſingle drop of ſolution of mercury forms
viſible clouds, although there be no more

K 3   than

than fix grains of newly cryftallized fal fodæ in a kanne of water.

Solution of mercury, made by long continued boiling in fuperabundant acid, is more dephlogifticated, as appears from the red vapours which it fends forth. This folution cryftallizes with more difficulty, and has a very acrid tafte. It is precipitated by vegetable alkali of a brownifh yellow, but by degrees affumes a paler yellow tinge; and, if the alkali be fully faturated with aerial acid, the precipitate is at firft of a brownifh yellow, but afterwards becomes of a yellowifh white. A brownifh yellow powder is precipitated by fal fodæ, this powder afterwards grows white. The precipitate occafioned by volatile alkali is white; that by vitriolic acid, either difengaged or united with any bafe, yellow; but the precipitate immediately grows white upon the affufion of a little marine acid. The fmalleft quantity of marine acid, either difengaged or otherwife, occafions a very copious white mucilaginous precipitate. — A blacknefs in the precipitate indicates either the prefence of an hepar, or that the mercury is nearly in its metallic ftate (o).

Mucilage

(o) It fometimes happens, not only that the precipitate is black, but that there appears upon the furface of the liquor a fhining pellicle, which announces a fpecies of revivification. When it is confidered, that fuch reductions are effected more efpecially by the volatile alkali, which

Mucilage is alſo precipitated by nitrated mercury : thus diſtilled water, containing three grains of cherry-gum in the kanne, on the addition of nitrated mercury inſtantly forms white clouds and ſtriæ.

(Q) *Corroſive ſublimate* is alſo in uſe for the examination of waters, eſpecially for the diſcovery of aerated alkali. If a kanne of diſtilled water contains 280 grains of newly cryſtallized ſal ſodæ, a ſingle grain of ſatu-

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which contains phlogiſton among its conſtituent parts, it would ſeem certain, that the precipitates are ſo much the more coloured, and the nearer reduction, as the liquor itſelf contains or receives from the precipitant more phlogiſton. Profeſſor Bergman furniſhes an additional fact in favour of this opinion, when he obſerves that volatile alkali produces a precipitate of a dark grey colour, when the ſolution has been made without loſs of phlogiſton ; and of a white colour, when red vapours ariſe during ſolution. He, however, eſtabliſhes here an oppoſite principle, viz. the more there remains of phlogiſton in the ſolution, the leſs is the precipitate coloured. Each, therefore, of theſe ſyſtems is inadequate to the explication of the phænomena. We want ſome further knowledge, in order to conciliate them, and to explain why, for inſtance, the ſame ſolution of corroſive ſublimate is precipitated of a yellow colour by lime-water, and of a white by cauſtic volatile alkali.

The author's obſervation is, notwithſtanding, not leſs valuable : it may enable us to diſcover why ſolutions of the ſame metal, in the ſame acid, are leſs permanent ; why ſolutions of metallic calxes are leſs apt to form depoſitions, when they proceed ſlowly, &c. Mr. Maret has already made a very happy application of this obſervation by ſhewing, in the Dijon courſe of lectures, that his proceſs for precipitating iron in the form of Ethiops martial, by cauſtic volatile alkali, never fails, but when a nitrous ſolution, made by heat, and with red vapours, is employed. Morveau.

rated

rated folution of corrofive fublimate imme-
diately produces a reddifh powder ; a fmall
piece of the fublimate itfelf, added to the
water, difcovers alkali, even better than the
folution.—The caufe of the rednefs of this
precipitate is explained elfewhere (*p*).

Both lime and magnefia, when aerated, by
means of a double elective attraction preci-
pitate a calx of mercury, though flowly.

(R) *Acetated lead* is precipitated in the form
of a white powder by the marine acid, either
difengaged or otherwife ; and this new com-
bination is foluble in vinegar, but is not a
convenient precipitant, becaufe falited lead
is alfo foluble in a large quantity of water :
it is more convenient for difcovering vitrio-
lic acid, for the precipitate or vitriol of lead,
which is in the form of fmall grains, is
fcarcely foluble in water, or even in vine-
gar. Diftilled water, containing 118 grains
of common falt in the kanne, fhews
ftriæ fomewhat milky, if a fmall piece of
acetated lead be laid on the furface ; upon
increafing the quantity of common falt,
the appearance becomes more remarkable.
Nearly the fame weight (115 grains) of
Glauber's falt is requifite, in order to oc-
cafion a vifible feparation of vitriol of lead
—and hence it would appear that thefe
two acids are almoft equally difcoverable by
acetated lead ; but we muft obferve, that in

(*p*) Treatife on the Aerial Acid, § xxi.

118 grains of common falt, the acid amounts to about 60 grains ; whereas in 115 grains of Glauber's falt, the acid is no more than 29½.—Now as vitriolic acid forms nearly 0,28 of vitriol of lead, we may, from the weight of the vitriol, in fome degree judge of the quantity of acid, if the water be compleatly precipitated by the acetated lead. However, when muriatic acid is prefent, which is almoft always the cafe, the conclufion is rendered inaccurate, on account of the much greater folubility of falited lead.

Acetated lead feems to lofe its acid fpontaneoufly by age, for a piece of it, when old, put into water, remains infoluble at the bottom.

A brown or black fediment indicates the prefence of fulphur in a ftate of folution ; alkalis, lime, and magnefia, diffolved in water by means of aerial acid, alfo precipitate lead, without the prefence of either marine or vitriolic acid. A fingle drop of folution of lead exhibits white ftriæ, in water containing no more than fix grains of newly cryftallized fal fodæ to the kanne.

(s) In fome cafes, *martial vitriol* promifes to be of ufe. If a cryftal of this falt be put into an ounce phial filled with diftilled water, the phial immediately well clofed, and fet in a cool place, the vitriol is diffolved, without depofiting any ochre, unlefs the water has taken up pure air, which very powerfully attracts phlogifton, and therefore

fore feparates a portion of it from the bafe of the vitriol ; fo that the bafe, being calcined, requires more acid than before to fufpend it ; and if the deficient acid be not added, the iron neceffarily falls in the form of an ochre. The fame is evidently feen, when the precipitation is effected by means of an alkali; for the fediment, which is at firft green, preferves its colour in a veffel full and perfectly clofed, provided the water be deprived of air, but in an open veffel it foon changes to a ferruginous colour ; becaufe, even though the water had not contained any air, the external air acts upon the precipitate. When the water does not contain any thing capable of precipitating the vitriol, a few drops of alkaline lixivium may be added before the veffel is fhut ; but if the water contains air, the alkali is not neceffary, as the bafe of the vitriol is quickly dephlogifticated ; and hence, as has been before obferved, the fame quantity of acid is not fufficient to diffolve it, and confequently fome ochre is depofited. If there be prefent at the fame time a confiderable quantity of aerial acid, the ochre is rendered white.—The quantity of ochre ferves in fome meafure to determine the quantity of air prefent.

It is alfo neceffary to obferve, that not only alkalis, but alfo lime and magnefia, united with aerial, marine, or nitrous air, decompofe martial vitriol, although a
precipitate

precipitate does not appear in every cafe ; for marine acid holds iron fufpended, although it be very much dephlogifticated.

(T) *White arfenic* is only ufeful when water is more or lefs impregnated with hepatic vapour, but does not contain a genuine hepar (x). If to fuch water a fmall piece of white arfenic be added, the arfenic grows yellow by attracting the fulphur, and is thus converted into orpiment.

(u) *Soap* is not foluble in every kind of water ; this is occafioned either by a difengaged acid, or by a large proportion of middle falt, with an earthy or metallic bafe ; in either cafe a decompofition takes place, the acid unites with the alkali, and the oil is difengaged : fuch waters as thefe are generally called hard waters, and are unfit for wafhing cloaths, as alfo for boiling pulfe, and the harder kinds of flefh.

Diftilled water fcarcely takes up 0,1 its own weight of foap, and that imperfectly, for it contracts an opal colour ; and after fome time the foap, which had been fufpended, falls to the bottom in the form of a mucilage. Spirit of wine acts upon foap more powerfully, for it takes up more than $\frac{1}{3}$ its own weight, after which it admits, without growing turbid, the addition of diftilled water, but not of hard. If there be prefent in a kanne of water but 8 grains of alum, falited magnefia, or falited lime, a fingle drop of this water occafions a turbidnefs

nefs in folution of foap in alcohol, diluted with an equal bulk of diftilled water.

(x) Some perfons add to the above-mentioned precipitants *hepar fulphuris*, becaufe it is decompofed by the weakeft acid, and even by the pureft aerial acid ; however, in the examination of waters, we may readily difpenfe with it, as well as with falited lime, alum, corrofive fublimate, nitrated mercury, (at leaft that prepared by heat) and acetated lead ;—the fame is true of milk. If to hepar fulphuris a fmall quantity of vitriolic acid be added, an elaftic vapour is immediately generated, with which water may be impregnated in the fame way as with aerial acid, and it will then poffefs the hepatic odour (VIII. E).

(Y) *Alcohol* added in fufficient quantity precipitates all the falts found in waters which are infoluble in fpirit of wine. Such are all thofe containing vitriolic acid, but thofe confifting of marine or nitrous acid are generally foluble, but require different quantities of fpirit for their folution (q). Here it may be ufeful to remark, that, according to experiments which I have made for the purpofe, alcohol, in an heat of 15 degrees, can take up, of dry nitrated magnefia, $\frac{1}{10}$ its own weight ; of dry falited magnefia, $\frac{1}{7}$; of dry nitrated lime, $\frac{1}{7}$; and of dry falited lime, $\frac{1}{6}$.

(q) Vid. M. Macquer Exp. in Comm. Taurenfibus.

Befides

Befides the precipitants already mentioned, many others have been employed, which, I imagine, we may pafs over untouched, as they difcover no more than thofe already propofed, nor are they more accurate. Nor indeed is it neceffary to employ the whole of the fubftances already examined :—it is true, that when time and circumftances permit, even fuperfluous trials are not improper, as they tend to confirm one another ; yet, for the moft part, a few, when well chofen, are fufficient for the purpofe.—For the difcovery of acids, when difengaged, we have occafion only for the tincture and paper of turnfole ;—when they are united with other fubftances, they are eafily difcovered by nitrated filver and falited terra ponderofa ; —uncombined alkalis are detected by the papers tinged with Brazil-wood and turmeric, and when combined with acids they are difcovered by fpirit of wine.—Aerated calcareous earths are precipitated by the acid of fugar ; and, when thus compleatly feparated, that fpecies which can afterwards be thrown down by aerated alkali is either magnefia or clay ; the former of which diffolves in diftilled vinegar, with efferve-fcence, while the latter is taken up flowly, and without any effervefcence.—Metals are plainly difcovered by phlogifticated alkali, but thefe, iron only excepted, are rarely found in waters ; fo that, for the moft part, tincture of galls is fufficient.—If terra pon-
derofa

derofa be at any time prefent, it. is difco-
vered by vitriolic acid.—Saline or earthy
hepar is very rarely found in the natural
cold waters, but may be eafily decom-
pofed by any acid whatever ; and when the
fulphur, which occafions a turbidnefs, is fe-
parated, the tranfparency returns.   In gene-
ral, water contains only an hepatic vapour,
which, though it refembles hepar in fmell,
is not decompofed by the addition of any
acid, excepting only thofe which, even
though diluted, powerfully attract phlogif-
ton ;—of this kind is the nitrous acid.   Be-
fides, at Aix pure air, out of the water, fe-
parates the fulphur from the hepatic vapour,
which in this inftance is not confined by
union with an alkali (VIII. E).

Finally, precipitants may be employed,
not only with the waters newly taken from
the fpring, but after they have been re-
duced by evaporation to a fmall bulk.—If
it be only neceffary to determine the qua-
lity of heterogeneous matters, one or two
cubic inches of the water, and a few drops
of the proper precipitants, will fuffice ; but
if we defire alfo to know the weight of the
different fubftances, large quantities of wa-
ter muft be fubjected to experiment, and
thefe fhould be conducted in tranfparent
glafs veffels.

§ VIII. *Method of collecting the heterogeneous volatile Matters.*

The elaftic vapours, refembling air, which are more or lefs abundant in waters, have occafioned confiderable difficulty in the examination of them; and the method of exactly collecting thefe volatile fubftances was unknown until the prefent age: befides, the methods at firft employed (fuch as agitation in a glafs veffel, with an empty bladder tied to its neck; or boiling the water, and conducting the vapour into a veffel filled with water, and inverted) were lame and imperfect;—for, in the former method, the whole of the volatile ingredient can fcarcely be elicited—and in the latter, no fmall part of that which is extricated is again concealed, being abforbed by the water through which it paffes.

But by the following method, that vapour, commonly known by the name of mineral fpirit, may, with the greateft accuracy, be feparated and collected.

(A) In proportion as the water is more fully impregnated with aeriform matter, the lefs is the quantity neceffary to be fubjected to examination;—of fuch as abound with it, half a quadrans is fufficient, and eight times that quantity of the very pooreft will be enough.—For this purpofe a glafs retort is employed, with a long narrow neck, the end of which is bended upwards, (A B C,

2   tab.

tab. ii. fig. 2.) The retort muſt be choſen of ſuch a ſize that the water may not boil out through the neck, nor yet too great a ſpace be left above the water, leſt too large a quantity of common air be included.

The quantity of water whoſe volatile vapour is to be determined, being put in, let the retort be ſo placed that it may be expoſed to heat; but before the fire is lighted let the glaſs veſſel D E, filled with mercury, be inverted over the extremity of the tube A B C, (which is turned upwards, and ſuſtained in the veſſel F G, full of mercury) in ſuch a manner that the mouth of the veſſel D E may be ſomewhat beneath the ſurface of the fluid metal in the veſſel F G. This operation requires a dexterous and experienced hand, to prevent the mercury from falling out during the inverſion of the veſſel; or, which comes to the ſame, to prevent the admiſſion of air into the veſſel D E : the ſize of that veſſel ſhould be ſuch that it may be able to contain all the elaſtic fluid extricated, together with the portion of common air contained in the retort above the ſurface of the water;—its capacity ought therefore to be ſomewhat greater than the ſum of the bulks of the air contained in the retort, and of the water under examination, if the water be ſaturated with elaſtic vapour; but if it be common water, a much leſs ſize will ſuffice.

The

The whole apparatus being properly pre-
pared, fire muſt be applied, and continued
to full ebullition.   The heat penetrating the
water, occaſions a quantity of bubbles,
which, increaſing as the heat increaſes, paſs
through the mercury, and are collected in
the upper part of the veſſel D E.   A few
minutes boiling will not indeed be ſuffi-
cient to expel all the elaſtic fluid, but the
portion remaining will be very ſmall, and
of little moment.

After this proceſs, let the height at which
the mercury ſtands in the inverted veſſel be
noted, and thus we may aſcertain the ſpace
apparently empty, in cubic meaſure.   If the
veſſel D E be cylindrical, and divided into
known parts of dimenſion, the bulk of the
elaſtic fluid appears barely from infpection ;
from hence, ſubducting the bulk of the
common air contained in the retort, the
bulk of the elaſtic vapour extricated from
the water is determined.——If this apparatus
be not at hand, a Florence flaſk, or ſome
other veſſel of proper ſize, may be uſed, and
a bladder, well compreſſed, tied to its neck,
to receive the vapour extricated by boiling:
but the concluſion in this caſe will be leſs
accurate.

Before the retort cools, the bended part of
the neck muſt be taken out of the mercury,
otherwiſe that metal will gradually fill the
retort ; for the apparent vacuum over the
ſurface of the water is only occupied by a

L   watery

watery vapour, which is reduced to the form
of water by cold (r).

(B) The

(r) The author here fuppofes, that the quantity of
mercury difplaced A C, in the cylin-
drical receiver here fketched, indicates
the quantity of elaftic fluid difengaged
by boiling; but this eftimation is not
exact, becaufe the air contained in
the fpace A C is in a greater ftate of
dilatation than the atmofpherical air ;
for inftead of being charged with the
whole weight of the atmofphere, it is
only charged with that weight, di-
minifhed by the weight of the column
of mercury C B ; fo that if the pre-
fent ftate of the barometer in the open
air is expreffed by H, the height of
the column C B by h, the denfity of the air in A C will be
to that of the open air, in the proportion of H — h to H. If
then the column C B is of feven inches, while the barometer
ftands at 28, four meafures of the air contained in A C
would be only equivalent to three, at the degree of conden-
fation of the open air. Further, the error may be total, *i. e.*
by following this method one might be led to believe
that there was air in water which contained none at all,
becaufe the air remaining in the neck of the retort, driven
by the ebullition into A C, will be the more expanded the
more the preffure of the air is diminifhed, or the higher
the column B C happens to be. Attention fhould there-
fore be paid to this dilatation, and it may eafily be afcer-
tained ; for if the volume of air remaining in the retort is
called v, the volume of mercury difplaced in the receiver
r, the height of the mercury in the barometer at the
time of the operation H, and the height of the column of
mercury C B, h, the quantity or bulk of the air really dif-
engaged from the water by boiling, and reduced to the
denfity of the atmofpherical air, will be $r - e - \frac{r\ h}{H}$. If, for
inftance, three meafures of air had been left in the retort,
and that air had difplaced four in the receiver, and the co-
lumn
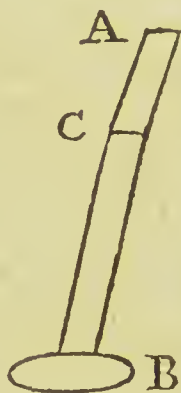
(B) The elaſtic fluid, thus collected, generally conſiſts partly of pure air and partly of aerial acid. To demonſtrate this, and (if both be preſent) to determine the quantity of each, one of them muſt be ſeparated; which is performed in this manner:—Let the aeriform fluid be agitated with lime-water, which may be introduced into the inverted veſſel, by cloſing it carefully, and transferring it from the mercury into a veſſel filled with lime-water, and then opening it; by theſe means the aerial acid is abſorbed, and the pure air, if any there be, remains alone—the bulk of which, ſubducted from the whole, ſhews the quantity of aerial acid (s).

(c) The

lumn of mercury c b had been 7 inches, and the barometer at 28, the quantity of air produced would be $4 - 3 - \frac{4 \times 7}{28} = 0$. Note, communicated by M. de Sauſſure to M. de Morveau.

(s) Mr. Gioanetti is of opinion, that the quantity of aerial acid may be better determined by weight than bulk : his method certainly does not require either an apparatus on purpoſe, or ſo much nicety: he puts into a large bottle two pounds of aerated water, and pours in a ſuperabundant quantity of lime-water, he then corks it; as ſoon as all the precipitate has fallen to the bottom, he ſeparates the liquor by means of a ſyphon, and, having edulcorated and dried the precipitate, eſtimates the weight of the aerial acid by the weight of the calcareous earth. In order to diſtinguiſh the uncombined aerial acid from that which might be united with ſome baſis, he repeats the ſame operation upon water deprived of its air by boiling. Mr. Gioanetti aſſumes, for the foundation of his calculation, the experiments of Mr. Jacquin; according to which, 32 parts of calcareous earth contain 13 of fixed air, 2 of water, and 17 of earth; but

this

(c) The aerial acid conftitutes the genuine *fpiritus mineralis* of the ancients, as is moft evidently demonftrated by the analyfis above propofed ; for all the mineral waters celebrated for virtue give out a confiderable quantity of an elaftic fluid (even fometimes a portion equal in bulk to the water itfelf) poffeffing all the properties of that fubtile acid ; and what puts the matter beyond doubt is, that if the elaftic fluid of fuch waters be either gradually diffipated in an open veffel, or fuddenly expelled by heat, the water lofes its grateful pungent acidity, which it recovers altogether, when the lofs of that elaftic fluid is fupplied: analyfis and fynthefis then agree fo perfectly on this occafion, that whoever confiders the operations with due attention muft be clearly fatisfied of the truth of the pofition—in another place, I have at large explained the method by which the natural aerated waters may be imitated.

It may happen, indeed, that the phlogifticated vitriolic acid (commonly called volatile acid of fulphur) fhall be mixed with the aerial acid, but moft undoubtedly this is a very rare occurrence: at leaft, I do

this eftimation differs from that of Profeffor Bergman by $\frac{53}{800}$; whence it appears, that it is not lefs difficult to determine with precifion the quantity of fixed air contained in calcareous earth than the proportion which the bulk of this fluid bears to its weight. See Analyfe des Eaux de St. Vincent, p. 14. Morveau.

not hefitate to affert, that the Pyrmont, the
Spa, the Seltzer, and other waters, whofe
penetrating and volatile efficacy has been at-
tributed to a difengaged phlogifticated vi-
triolic acid, do not contain the fmalleft par-
ticle of it. Thefe waters, upon analyfis, are
found to contain lime and magnefia aerated,
and the laft (the Seltzer) alfo contains an
aerated mineral alkali, which is utterly in-
compatible with the exiftence of a difengaged
vitriolic acid ; for this acid, to whatever de-
gree it may be phlogifticated, attracts lime,
magnefia, and alkali, with a force fuperior
to that of the aerial acid ; if prefent,
therefore, it muft expel the weaker acid, and
take its place—that is, it muft lofe its difen-
gaged ftate. The prefence of phlogifticated
vitriolic acid cannot therefore be afferted,
without a palpable contradiction, fo long as
any aerated alkaline fubftances are found in
the fame water. It is alledged, indeed, that
this decompofition cannot take place in the
bofom of the earth, and no doubt (t) that
is fometimes the cafe ; but it certainly
cannot hold with refpect to Pyrmont, of
which, however, it is particularly afferted,
for, at its very firft appearance, upon the
addition of fpirit of wine, it feparates its
magnefia and lime compleatly vitriolated.
No perfon who has feen or examined the
phlogifticated vitriolic acid, can poffibly

(t) Aerial Acid, fee p.

L 3   confound

confound it with the aerial acid ; for
the fmell of the former is pungent and
highly penetrating, that of the latter fcarce
fenfible : the tafte of the former, acrid and
naufeous ; that of the latter, very mild and
agreeable : the former may be reduced to a
liquid form, the latter is always in a ftate of
vapour : the former, being ftronger, expels
the latter from every kind of bafe, and forms,
with each of them, compound falts of a
fpecies very different from thofe formed by
the fame with aerial (v) acid ;—in fhort,
they fcarcely poffefs any property in com-
mon, excepting only the general properties
of acids. If the opinion of fuch as confound
thofe two acids were well-founded, the for-
mer would not change the colour of fyrup
of violets, which the latter is never found
to do ; but I have always obferved that
phlogifticated vitriolic acid, unlefs when
mixed with iron, changes fyrup of violets
to a red.

(D) Waters abounding with fixed air, as
I before obferved, poffefs a pungent but
agreeable acefcent flavour; and from hence,
doubtlefs, it is that from the moft remote
times they have been called *acidulæ*.
The propriety of this denomination is call-
ed in queftion by many perfons at this day,
becaufe thefe waters effervefce with acids
and not with alkalis ; and alfo change the

(v) Treatife on elective Attractions.

colour

colour of fyrup of violets to a green; which are confidered as certain figns of an uncombined alkali.   But here we muft obferve, 1ft, that, ftrictly fpeaking, effervefcence with acids never indicates a pure alkali, but an alkali united with the aerial acid, which, upon the addition of a more powerful acid, is feparated, and, recovering its elafticity, muft float in the form of bubbles on the furface of the more ponderous fluid; whereas an alkali perfectly cauftic does not excite the fmalleft effervefcence with acids : 2d, a fimilar effervefcence alfo takes place, when lime or magnefia aerated meet with an acid; and this is the cafe with Pyrmont water, which does not contain any aerated alkaline falt—Spa water, indeed, contains a fmall portion, and Seltzer ftill more : 3d, alkaline fuftances, whether faline or earthy, though faturated with aerial acid, yet act as precipitants, in virtue of their alkaline nature, and exert a certain force upon various bodies, which force is not altered by the aerial acid, on account of its extreme weaknefs; this force is however fomewhat diminifhed, though it can be entirely fuppreffed by the quantity of acid neceffary to the faturation of the alkaline falt and the water which diffolves it : 4th, the aerial acid cannot effervefce with alkalis, becaufe it is the expulfion of this acid by a ftronger one that occafions the motion and the fpumefcence, appear-

ances

ances which are not occasioned by the meeting of an alkali with the aerial acid. Thus the moſt completely aerated Pyrmont or Seltzer water, upon the addition of a ſmall quantity of alkaline ſalt, particularly if cauſtic, immediately grows flat, and acquires a vapid taſte, and that without any viſible motion : 5th, the green colour induced upon ſyrup of violets is evidently a fallacious teſt (VII. c) ; for diſtilled water, in which a ſmall quantity of martial vitriol is diſſolved, poſſeſſes the property of immediately rendering that ſyrup green.

Since, then, in the acidulous waters not only the alkali is ſaturated with aerial acid, but the water alſo contains it ſo copiouſly as to render tincture of turnſole red, ſuch waters cannot properly be conſidered as alkaline. This acid, though ſuperabundant, is ſo weak, that it is not able totally to repreſs the alkaline properties ; it is alſo volatile, but neither its weakneſs nor its fugacity can ſubvert its eſſential properties.

(E) From the ſulphurated hot waters an hepatic vapour is collected, the preſence of which is readily diſcovered by its peculiar fætor : this is ſometimes preſent, together with aerial acid diſengaged, and it is decompoſed, when it has quitted the water, by pure air ; which cannot appear ſurprizing, as concentrated nitrous acid is capable of effecting that decompoſition, even in the water. The explanation of both is the fame :

fame: thus the hepatic aura is tenacious of its form of vapour—hence a very large and dry furface of contact is prefented to the atmofphere, in confequence of which the pure air feizes the phlogifton, which in a hepatic vapour connects the fulphur with the matter of heat, and thus, the bond of union being removed, the fulphur appears in its proper form. This is the origin of the fulphur which is fublimed at Aix la Chapelle; hence too, we underftand how hepatic vapour is quickly decompofed, and depofits its fulphur, upon the addition of any fubftance which is capable of feparating the phlogifton.—I before mentioned the con-ftituent parts of hepatic vapour; but as this is particularly examined in the Treatife on fubterranean Fire, I omit the analytical de-monftration of it here.

(F) The volatile falts, which, if I may be allowed the expreffion, are more corporeal when they happen to be prefent, are found to be driven over into the recipient, or fome-times, though very rarely, adhering to the neck of the retort, as the watery vapours diffolve and carry them over; this applies particularly to volatile alkali and the ammo-niacal falts, which may be eafily feparated by the precipitants defcribed (§ VII). Some-times however, the water, paffing over alfo, contains a portion of acid, which, upon ex-amination, is found to be of different forts; thus, when nitrated lime or magnefia is pre-

7   fent,

fent, the nitrous acid comes over, becaufe the conftituent principles of thofe falts co-here fo loofely, that they are feparated by boiling, if continued for any length of time : but the muriatic acid cannot, by this degree of heat, be feparated from any falt, except falited magnefia ; the phlogifticated vitriolic acid may alfo be obtained in this manner, if it be uncombined—the quantities of the falts thus decompofed may be difcovered by faturating the acids refpectively with bafes of the fame fort with thofe from which they have been expelled.   The weight of the new compound indicates the quantity of falt decompofed by the fire.

§ IX.   *Method of collecting the fixed hetero-geneous Matter.*

During the evaporation of the water, the fixed heterogeneous matters are continually reduced to narrower compafs, and at length the water becomes infufficient to retain them all ; hence they are feparated by degrees, the leaft foluble firft, and then fuch as require lefs water for their folution.—I fhall now proceed to defcribe the method of conduct-ing this operation more particularly.

(A) The veffels employed ought to be broad, becaufe fluids evaporate more or lefs quickly, in proportion to their furfaces. We may fafely employ for this purpofe earthen veffels, provided they are fo com-

pact as not to abforb any faline matter, with
a denfe and fmooth furface, which will not
be liable to defquamation, fo that fuch mat-
ters as adhere to it during evaporation may
be eafily feparated, and fcraped off pure.
Iron and copper are corroded, and therefore
are in general altogether unfit for this pur-
pofe : neither is tin convenient : filver, be-
fides being expenfive, is fometimes unfafe,
efpecially if there be any uncombined ni-
trous acid in the water : veffels made of
ftone-ware are excellent in many refpects,
but are liable to two objections ; for, firft,
their furface is fomewhat rough, hence a
part of the refiduum may eafily be conceal-
ed in the holes and inequalities ; and, fe-
condly, they are foft, fo that fuch particles
as adhere very clofely cannot be fcraped off,
without danger of fcraping off alfo a part
of the veffel : glafs veffels would be the
moft convenient, if the operations could al-
ways be conducted in them without break-
ing;—fmall and fufficiently thin glafs veffels
may, without danger, be expofed to an in-
tenfe open fire, if properly regulated, but
fuch as are neceffary for containing large
quantities require for that purpofe a fuffi-
cient degree of thicknefs ; and hence, being
unfit to endure fudden changes of heat and
cold, are eafily broken. The fize of the
veffels depends upon the quantity of water
neceffary for the feveral experiments.

(B) The

(B) The quantity of water neceſſary to be ſubjected at one time to experiment is generally determined by the quantity of heterogeneous contents; if theſe are abundant, one kanne is ſufficient, but when the quantity is ſmall, ſix, eight, or more are requiſite. If our veſſels are not of ſize ſufficient to contain the whole quantity at once, we muſt add the water from time to time, according as room is made by the evaporation; but this muſt be done with great circumſpection, left the warm veſſel ſhould be broken by the coldneſs of the water.

(c) A gentle evaporation is moſt proper, for by violent ebullition a portion of the ingredients is diſſipated, nay, ſometimes decompoſed. A cover is neceſſary, to keep out the charcoal, duſt, and embers; this cover muſt give exit to the vapours by an hole ſeveral inches in diameter, but the hole ſhould be kept ſhut until the iſſuing vapour is ſo far condenſed as to prevent the duſt from falling in.

(D) In this proceſs different phænomena appear, according to the different contents of the water. If there be preſent lime and iron aerated, in an intenſe degree of heat, ſuch as $80°$ or $90°$, they are deprived of the quantity of aerial acid neceſſary to render them ſoluble; they collect therefore on the ſurface, where the volatile menſtruum firſt becomes deficient, and form a pellicle, which being broken by the agitation

tion of the water, falls to the bottom when the motion ceafes. This happens becaufe lime and iron, when barely faturated with aerial acid, refufe to unite with water, but may be taken up when this fubtile men-ftruum is fuperabundant in the water. This fuperabundance adheres to them but flight-ly, and therefore flies off during evaporation; — which alfo happens fpontaneoufly, upon keeping the water for fome days in an open veffel.

The above-mentioned pellicle is found whole, when formed by iron; and in this cafe it is tinged with the different prifma-tic colours, according to the different points of view. It has been thought that this contained a certain bituminous oil, particu-larly becaufe it detonates with nitre, but not the fmalleft particle of this unctuous matter has as yet been difcovered in it. As to the detonation, that is occafioned, in the prefent cafe, by the phlogifton remaining in the martial earth, which when frefh contains fo much of that principle that it is foluble in all acids.—But this remainder of phlogifton is gradually diffipated, and that the more quickly, and in proportion as it has been expofed to the more heat during evapora-tion, and to the more free accefs of atmo-fpheric air. The fimultaneous variation of colour indicates nothing more than various degrees of tenuity, or various ftates of de-phlogiftication in the particles.

If

If aerated magnefia be prefent in water, it is not feparated all at once, but continues to fall by degrees during the whole procefs, from the beginning of the evaporation even to drynefs.

Aerated lime and filiceous particles fall rather before a boiling heat.

Of all the falts, gypfum falls firft, but not until long after aerated lime and aerated iron.

If faturated folutions of different falts be mixed, they all appear, during the evaporation, in an order conformable to their degree of folubility; that is, fuch as are leaft foluble in water appear firft : — thus alum is the foremoft, then vitriolated vegetable alkali (if any there be) afterwards, in order, martial vitriol, common nitre, vitriol of copper, falited vegetable alkali, mineral alkali, common falt, vitriol of zinc, vitriolated magnefia, and, laftly, the deliquefcent falts : but this order is frequently interrupted by the quantity of the diffolved matters.

The different heterogeneous matters may accordingly be either feparated as they fucceffively appear, or, by continuing the evaporation to drynefs, be obtained all mixed together. The former method is in fome inftances fufficiently commodious, but is generally of little ufe, efpecially when aerated magnefia is prefent, as this fubftance does not feparate altogether ; befides, the falts, however carefully collected in this way, are

more

more or lefs mixed with each other, and the deliquefcent falts occafion much inconvenience, efpecially about the end of the operation. If every particular ingredient is to be feparately and accurately collected, the water muft be frequently filtered, a procefs which is attended with as much trouble as the repeated folution and evaporation of the refiduum, but is much more uncertain, on account of the particles which are loft upon the filter—hence the latter method appears to be more eligible. If circumftances permit us to repeat our analyfis, the former method may be tried, for the fake of comparifon.

(E) The evaporation being continued to drynefs, the whole refiduum fhould be carefully collected, and, if thought neceffary, weighed; but the weight of the whole will be more accurately determined from the fum of the feveral ingredients; becaufe, on account of the inequality of exficcation, more or lefs of the water of cryftallization may be expelled.—Such falts as can be reduced to the form of cryftals, fhould be weighed when in that form.

§ x. *Examination of the Refiduum not foluble in Water.*

(A) The whole refiduum, well dried, is then put into a bottle, and alcohol poured over it, to the height of an inch; the veffel is then fhut clofe, and fhaken; and,

after

after ftanding for a few hours, the liquor is filtered.

(B) To the refiduum is then added eight times the quantity of cold diftilled water; the mixture fhaken; and, after ftanding fome time, it is filtered.

(c) Finally, the refiduum is boiled for a quarter of an hour in fomewhat more than four or five hundred times its weight of diftilled water, and afterwards filtered.

(D) The refiduum now is not foluble, either in fpirit of wine, or water. If it abounds in particles of iron, let it be ex- pofed in an open veffel for fome weeks to the rays of the fun, and moiftened from time to time; by thefe means the metal is fo much dephlogifticated, that it is not fo- luble in vinegar (an effect which may be produced in a fhorter time, by means of heat) but at the fame time the magnefia is calcined, and the weight fuffers a (u) dimi- nution. The prefence of iron is very eafily difcovered by the brown colour. The flow calcination by the fun's rays occafions no inconvenience, for the refiduum being dry, a traveller may eafily carry it with him wherever his occafions lead him.

The refiduum generally confifts of three or more ingredients mixed together; thefe may be feparated from each other by the following method :— 1ft, Upon this refi- duum, previoufly calcined, if neceffary, and

(u) Diff. on Aerial Acid.

weighed,

weighed, is poured diftilled vinegar, which, by digeftion, diffolves the aerated lime and magnefia remaining in the refiduum. Any mineral acid may be employed for this pur- pofe, if there be no iron prefent, a circum- ftance which ought to be previoufly exa- mined by the colour and by the precipitants above defcribed ; but as there is fometimes prefent an argillaceous matter, which is more eafily taken up by the mineral acids, I rather recommend the ufe of diftilled vine- gar. The refiduum, which is not taken up by the vinegar, when wafhed and dried, fhews, by its lofs of weight, how much has been diffolved.

2dly, The acetous folution, evaporated to drynefs, yields acetated lime, filamentous, and refembling mofs. This fubftance is permanent in a moift air, if it only confifts, of lime ; but deliquefcent, if it contains magnefia. This point may alfo be further afcertained by diluted vitriolic acid (which, to guard againft fuperabundance, fhould be dropped in fparingly and flowly) ; for this acid, in the former cafe, converts the whole mafs into gypfum, which falls to the bot- tom, and is nearly void of tafte ; but in the latter, it diffolves the magnefia perfectly, forming vitriolated magnefia extremely bitter, and which, on evaporation, forms prifmatic cryftals ; or, if the bafe be mixed, it forms partly gypfum, partly vitriolated magnefia.

M   3dly, In

3dly, In order to know the weight of fo-
luble earth which had been fufpended in the
water, let the gypfum and vitriolated mag-
nefia be feparately diffolved, precipitated by
an aerated alkali, wafhed, dried, and weigh-
ed ; but this tedious procefs may be avoided,
if we recollect that 100 parts of gypfum
contain about 34 of pure lime, which are
equivalent to nearly 62 of aerated lime ; and
that 100 parts of vitriolated magnefia con-
tain 19 of pure magnefia, which are equal
to 42 of aerated magnefia.

4thly, That part which is not foluble in
the vinegar, is either argillaceous, martial,
or filiceous. The prefence of the firft al-
ways renders the water fomewhat turbid, and
of an opal colour ; this, as well as the mar-
tial earth, is foluble in marine acid, but the
metallic earth may be precipitated alone by
a phlogifticated alkali ; after which, the ar-
gillaceous part may be thrown down by an
alkali. Such portion as refifts a fufficient
quantity of marine acid, is filiceous earth,
which may be further determined by the
blow-pipe ; for this earth, when added to
the mineral alkali in fufion, unites with it,
with a violent effervefcence, and is thereby
totally diffolved (e).

5thly, Aerated

(e) Mr. Gioanetti (l. c. p. 22.) is of opinion, that the
quantity of iron may be determined by precipitation with
galls ; he pours in the infufion till there is a fuperabun-
dant quantity, and he afterwards expofes the precipitate to
heat

5thly, Aerated manganefe may, perhaps, fometimes be difcovered in waters; in which cafe it is found in the refiduum, N° 4, and may be feparated in the following manner :— Firft let the refiduum be violently calcined, then pour upon it diluted nitrous acid, with the addition of a little fugar; and, after ftanding for about an hour, let the liquor be filtered. Upon dropping an alkali into the filtered liquor, a white powder falls, which, by ignition, grows black, and the weight of which is to be determined by the balance. The rationale of this operation will readily appear (ƒ) hereafter; I therefore pafs it over here, in order to avoid repetition as much as poffible.

6thly, If at any time aerated terra ponde-rofa is contained in the refiduum (which certainly may be the cafe, although no per-fon has hitherto difcovered it) it diffolves in vinegar like the other abforbent earths, and differs from lime in this particular, that it forms, with vitriolic acid, a fpathum pon-derofum, which is not foluble in a thoufand times its weight of water. 100 parts of

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heat in a luted crucible;—it lofes about $\frac{3}{4}$ of its weight, and becomes fenfible to the magnet. This procefs may be ufeful to verify or compare refults, but alone is not fuffi-cient, as it affords no indication of the ftate of the iron, nor of the menftruum. Befides, the great diminution of the precipitate after calcination, does not allow us to fup-pofe that its magnetic properties are deftroyed by excefs of phlogifton. Morveau.

(ƒ) Of the white Ores of Iron.

this

this fpar contain about 84 of pure terra ponderofa, which are nearly equivalent to 130 of that earth when aerated.

§ xi. *Examination of the Refiduum foluble in Water.*

We fhall now proceed to examine the folutions mentioned in the preceding fection.

(A) The folution obtained by alcohol (x. A) contains chiefly lime and magnefia falited, lime and magnefia nitrated, together with falited terra ponderofa, if one or more of thefe fubftances be contained in the water. In order to difcover the quality and quantity of the ingredients, evaporate to drynefs, pour on diluted vitriolic acid, and continue the procefs as defcribed (x. D, 2, 3.) Sometimes the alcohol alfo contains a dephlogifticated martial vitriol, which may be feparated from the folution, diluted with a fufficient quantity of water, by a phlogifticated alkali. The folution is of a reddifh brown.

(B) The folution made by cold water (x. B) is to be thus examined: 1ft, cryftallization is to be attempted by gentle evaporation—this cryftallization fucceeds better, when the deliquefcent falts are feparated. Excepting common falt (of which cold water diffolves nearly as much as hot, and which therefore is cryftallized by continual evaporation)

evaporation) all the falts eafily affume re-
gular forms, if the evaporation be carried
on in a heat of 80° or 90°, until a drop
of the folution let fall upon a cold glafs, in
the fpace of a minute exhibits cryftalline
grains or fpiculæ. Slow refrigeration is
alfo preferable to a quick one. Evapora-
tion conducted with a boiling heat, will
fometimes produce perfect cryftals on the
furface; but thefe generally confift of an
aggregation of various forts. When we are
only enquiring into the fpecies of the falt,
and not its figure, we muft proceed in an-
other way :—

Let the cryftals which fucceffively ap-
pear be put upon bibulous paper and dried,
but not fo much as to expel any of the
water of cryftallization: the form, tafte,
and other qualities, mentioned in D, will
in fome meafure ferve to determine the
true nature of each falt; but in order to
avoid the fmalleft doubt, we fhall confider
them all in the following manner: in N° 2,
alkaline falts alone are comprehended; 3,
neutral falts; 4, earthy falts; 5, metallic
falts; and, finally, 6, a number of mixed
falts, which are feparated with more diffi-
culty.

2. Whether any given falt be alkaline or
not, may be difcovered to a certainty by
various methods; *viz.* by its lixivious tafte,
effervefcence with acids, and the various
precipitants (VII. B, C). By uniting it

with

with vitriolic (*g*) acid, we may determine the species of alkali.

Authors speak of a certain imperfect mineral alkali; but all of that sort, which I have had an opportunity of seeing, appear to be no other than a genuine alkali, but impure, particularly vitiated by deliquescent salts. But we shall have occasion, perhaps, to say more of this hereafter.

3. I call those salts *neutral*, which are composed of an acid and an alkali; and I call those *middle* salts, which have not a saline, but an earthy, or metallic base. Perfect neutral salts, such as are found in water, do not shew any signs either of acid or alkali in a disengaged state, nor are solutions of them rendered in the least turbid on the addition of an alkaline salt.

In the examination of either neutral or middle salts, two circumstances must be particularly attended to; namely, 1st, to determine what the constituent acid is; and 2d, what base the acid is united with.—Vitriolic acid is discovered by salited terra ponderosa (VII. F, L) or by acetated lead (VII. R). When the nitrous acid is present, it is expelled by the affusion of concentrated vitriolic acid, and may be distinguished by its peculiar smell, and its red

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(*g*) Distilled vinegar is preferable, as it forms, with vegetable alkali, a deliquescent salt, and with the fossil a foliated crystallizable salt. Morveau.

smoke,

ſmoke.   In like manner marine acid yields to the vitriolic, but has a different kind of ſmell, and a grey ſmoke.   When theſe acids are only in very ſmall quantity, the ſmoke will ſcarcely be viſible in a dry place ; but in this caſe the very ſlighteſt veſtige of nitrous acid is made apparent, by expoſing to the fume a paper moiſtened with volatile alkali.   To diſcover the moſt minute quantity of marine acid vapour, nothing more is neceſſary than a paper moiſtened with water : the vapour inſtantly ſurrounds this paper, in the ſame manner as the nitrous vapour attaches itſelf to the paper impregnated with volatile alkali.

Beſides, nitrous acid is diſcoverable by detonation ;   and the marine, by various means, ſuch as nitrated ſilver (vii. o), nitrated mercury (vii. p), and acetated lead (vii. r).

It is ſomewhat more difficult to diſcover the baſes ;   the vegetable alkali cannot be ſeparated in the humid way, unleſs by terra ponderoſa ; but this ſeparation may be effected in various ways, by means of a double elective attraction (h).   The mineral alkali is expelled by the vegetable, but in this caſe does not manifeſt itſelf by turbidneſs (i) ; yet it may be diſcovered by cryſtal-

(h) On elective Attractions.
(i) Ibid. § vii. ſub initio.

M 4.   lization.

lization. Both the fixed alkalis expel the volatile, with a peculiar pungent odour.

Vitriolated mineral alkali fhould be carefully diftinguifhed from the combination of vitriolic acid with magnefia. Thefe two falts agree in forming bitter prifmatic cryftals, which fuffer fpontaneous calcination in a dry air; but the cryftals of the former are generally larger, much depreffed, with a cooler and milder tafte; but they may very eafily, and inftantly, be diftinguifhed from each other, by the addition of a fmall piece of each to lime-water; for the lime-water is not rendered in the leaft turbid by the vitriolated mineral alkali, but the vitriolated magnefia is inftantly decompofed; for in this laft cafe the acid unites with the lime, and forms a gypfum, which, together with the deferted magnefia, is found at the bottom. If thefe, mixed together, be prefent in water, they cannot be completely feparated by cryftallization. I determine the quantity of each in the following manner: I gradually precipitate the magnefia by a folution of mineral alkali; I unite this again with vitriolic acid, and obtain, by cryftallization, a vitriolated magnefia; the weight of which, fubduĉted from the whole mafs of faline matter, previoufly cryftallized and weighed, yields the weight of the vitriolated mineral alkali. The fame may be colleĉted from the weight of the precipitated magnefia alone, if we know the proportions

of

of the principles which conftitute the two falts. Authors fpeak of many varieties of vitriolated mineral alkali, and vitriolated magnefia, varieties which, however, depend entirely upon the difference of purity : thus the fal Anglicus, Epfom falt, Leydfchutz falt, Seidlitz, and others, when well depurated, all yield the very fame vitriolated magnefia.

The vegetable and mineral alkali, when united with marine acid, form falts which agree in their cubic figure, decrepitation in the fire, and to a certain degree in their tafte ; yet the former is fomewhat more acrid, and is befides perfectly diftinguifhable by another property, for if into a faturated folution of this falt be dropped the acid of tartar, a pure and genuine tartar falls to the bottom ; this does not take place in a folution of common falt, becaufe the mineral alkali has far lefs affinity with acid of tartar than the vegetable alkali has.

4. If the bafe of the falt be earthy, which is known by its precipitating on the addition of aerated alkali, the fpecies of the earth may be thus determined :—terra ponderofa produces, with the vitriolic acid, a fpathum ponderofum (x. D, 6) ; calcareous earth, with the fame acid, produces a gypfum (x. D, 2) ; magnefia, the falt commonly called fal catharticus amarus (x. D, 2) ; and clay produces alum.

5. If

5. If any metal be prefent, it may generally be known by the colour, or by an ochre.—If the bafe be cupreous it is precipitated in a metallic form upon iron, if the moiftened falt be rubbed upon the metal, or a polifhed piece of iron laid in the folution; it is difcoverable alfo by a blue colour, an æruginous tafte, by the volatile (VII. 1), or by the phlogifticated alkali (VII. E).

Iron is detected by its colour, which is greenifh, or yellowifh, according to the degree of dephlogiftication, by its inky tafte, by an ochre, by tincture of galls (VII. D), and by phlogifticated alkali, which precipitates a Pruffian blue (VII. E).—In the Treatife on Alum, I fhall explain at large the method by which martial vitriol may be feparated from vitriolated magnefia and alum.

Zinc forms, with vitriolic acid, a white vitriol, of which cryftals have a prifmatic figure.—This metal is precipitated white by alkalis; as alfo by the phlogifticated alkali; but is not at all affected by any metal.

Manganefe alfo yields a white vitriol and white precipitates; but it differs from zinc in growing black by calcination, and being afterwards infoluble in acids, unlefs they are either themfelves phlogifticated, or rendered fo by the addition of fome fuitable fubftance, fuch *v. g.* as fugar.

Arfenic, in its reguline form, is not foluble in water; and of the white calx of arfenic, cold water takes up no more than

10   a few

a few grains in a karine;—befides, this calx is very rarely found naturally foluble in water; neverthelefs, as it may fometimes happen, efpecially in countries abounding with metals, that water fhall be vitiated by arfenic, I fhall here fhew by what method it may be difcovered.

If the dry refiduum be thrown upon live coals, or, which is better, expofed upon a piece of charcoal to flame, by means of a blow-pipe, a fmell like that of garlic will be diftinctly perceived;—this is the moft certain indication of the prefence of arfenic. Many other methods have alfo been thought of, but they are in general fuch as cannot be employed, unlefs the water contains arfenic alone, which is feldom or never the cafe.—If a clear folution of hepar fulphuris be dropped into water containing arfenic, and no fubftance be prefent to prevent it, a yellow precipitate immediately falls, which is found to be a fpecies of orpiment or fulphurated arfenic.

6. The various falts, although very different from each other, when once mixed together, are not eafily feparated; hence often arifes confiderable difficulty in the analyfis of waters; for certain of the neutral and middle falts, enter into more compound combinations, and obftinately refift feparation, even though cryftallization be many times repeated; at leaft they adulterate

terate one another, and are not obtained pure without the utmoft difficulty.

This difficulty has already been in fome degree removed by feparating the delique-fcent falts (x. A), which otherwife would enter the water neceffary for cryftallization, and prevent that procefs from going on regularly.—The following are the principal inconveniences which ftill remain :—

The uncombined mineral alkali can fcarce be perfectly feparated from common falt : the weight of both thefe taken together being known, let the alkali by degrees be exactly faturated with vitriolic acid ; this being done, let an equal quantity of the fame acid be faturated with mineral alkali ; which being cryftallized, the weight of alkaline falt mixed with the common falt, and confequently the weight of the fea-falt itfelf, will appear (k).

We

(k) As the operator can never be fure of attaining the precife point of faturation, even though he fhould ufe the precautions of diluting the acid or alkali, and mixing a tincture with the liquor; that he may be able to perceive the progrefs of its changes, the procefs of M. Gioanetti to obtain the feparations of the fame falts feems more advantageous ; it confifts in reducing all the foffil alkali into foliated earth, by the addition of a fufficient quantity of diftilled vinegar ; and, after cryftallizing the whole mafs again, to diffolve the terra foliata in fpirit of wine : the fole attention neceffary is, not to burn the terra foliata, and confequently to evaporate by a very gentle heat. The learned phyfician of Turin found that fpirit of wine would not take up fea-falt, even when mixed with terra foliata. By diftilling the fpirit of wine, and cal-cining

We have already fhewn (B. 3) how mineral alkali and magnefia, when united with the fame vitriolic acid, as alfo vegetable and mineral alkali, when falited, may be feparated ;—the weight of the whole and of one ingredient being known, that of the other is eafily determined.

Alum and vitriolated magnefia are feparated by chalk, but not by quick lime, which decompofes both ; whereas chalk, or rather aerated lime, decompofes alum, but induces no change upon vitriolated magnefia.

Finally, if diftinct concretions cannot otherwife be obtained, the metallic falts are to be precipitated by phlogifticated alkali; the earthy ones by fixed alkali, and the precipitates managed as directed (x. D) : the quantities of the precipitating alkalis, and of the falts produced by their means, cannot fail to give the requifite information (D).

(c) The folution made by boiling water (x. c) contains fcarcely any thing more than gypfum, which may be either feparated by cryftallization, or decompofed by an alkali.

(D) In order that the different falts may be the more eafily diftinguifhed, and their

_____

cining the refiduum, the foffil alkali which exifted in the firft faline mafs will be retrieved in fubftance without mixture. The quantities then may be verified in this cafe, both by fubtraction and addition, and by procuring the matter itfelf. Morveau.

<div align="right">mutual</div>

mutual relations the better underſtood, I add the following ſketch of the moſt remarkable among them, having treated elſewhere of the aerated alkalis.

Vitriolated vegetable Alkali ; vulgo vitriolated Tartar.

(*l*) 100 parts contain about 52 of pure vegetable alkali, 40 of vitriolic acid, and 8 of water. In an heat of 15° one part of this ſalt requires, for ſolution, 16 of water, but of boiling water no more than 5. The taſte is weak and ſomewhat bitter ; it does not deliqueſce in a moiſt, nor ſuffer ſpontaneous calcination in a dry air ; it decrepitates in the fire, and is fuſed with difficulty.

The original form of the cryſtals is that of an hexagonal priſm, terminated at both ends by an hexaedral pyramid.—The accidental figure varies in many different ways.

(*l*) I ſhall ſubjoin Mr. Kirwan's eſtimation of the reſpective quantity of ingredients in theſe ſaline compounds. The reader will probably be ſurprized at the difference between his numbers and thoſe of the author ; but ſuch problems are among the moſt difficult in chymiſtry. There is, however, a circumſtance which muſt not be concealed, and which will contribute to reconcile much of the difference :—Mr. Kirwan conſiders the acids as pure, and totally free from water ; whereas Profeſſor Bergman conſiders them in a ſtate of conſiderable concentration indeed, but as containing a very large proportion of water.

100 grains of this ſalt, perfectly dry, contain, according to Mr. Kirwan, 30, 21 of real acid, 64, 61 of alkali, and 5, 18 of water : when cryſtallized, they contain 6, 18 of water. B.

Vitriolated

Vitriolated mineral Alkali; vulgo *Glauber's Salt.*

(*m*) 100 parts contain 15 of pure mineral alkali, 27 of vitriolic acid, and 58 of water. In a moderate heat, one part requires $2\frac{6}{7}$, of water, of boiling water only $\frac{4}{5}$.—It does not deliquefce in a moift air; it fuffers fpontaneous calcination in heat; it liquefies in the fire, again grows dry, and then fufes.—The tafte, bitter and cold.

The form irregular hexagonal prifms; two oppofite fides broader, the apices oblique, formed of two planes, confifting of the two oppofite narrow fides of the prifm, inclined to each other in a manner refembling the roof of an houfe.

Nitrated vegetable Alkali; vulgo *common Nitre.*

(*n*) 100 parts contain 49 of pure vegetable alkali, 33 of nitrous acid, and 18 of water; one part requires 7 of water, but of boiling water fcarce more than 1. The tafte, acrid, bitterifh, cold;—it neither de-

(*m*) 100 grains, perfectly dry, contain 29, 12 of mere vitriolic acid, 48, 6 of mere alkali, and 22, 28 of water. —In cryftals they contain 13, 19 of vitriolic acid, 21, 87 of alkali, and 64, 94 of water. B.

(*n*) 100 grains, perfectly dry, contain 30, 86 of acid, 66 of alkali, and 3, 14 of water.—In cryftals they contain 29, 89 of acid, 63, 97 of alkali, and 6, 14 of water. B.

liquefces

liquefces nor efflorefces ;—it detonates with ignited phlogifton.

The form prifmatic, hexagonal, often ftriated. The apices hexagonal, pyramidal, generally obliquely truncated.

Salited vegetable Alkali ; vulgo Sal digeftivus Sylvii.

(o) 100 parts contain 61 of pure vegetable alkali, 31 of marine acid, and 8 of water ; 1 part requires, for folution, 3 parts of water in a moderate temperature ; of boiling water 2. The tafte falt and acrid ; it neither fuffers deliquefcence, nor fpontaneous calcination ; it decrepitates in the fire, and fufes.

The form cubic, fometimes prifmatic, quadrangular, perpendicularly truncated.

Salited mineral Alkali ; vulgo Sea Salt, or Muria.

(p) 100 parts contain 42 of pure mineral alkali, 52 of marine acid, and 6 of water. One part in a moderate heat requires $2\frac{14}{17}$ of

(o) 100 grains, perfectly dry, contain 29, 68 of acid, 63, 47 of alkali, and 6, 14 of water ; but when cryftal-lized they contain 7, 85 of water. B.

(p) 100 grains, perfectly dry, contain nearly 35 of real acid, 53 of alkali, and 13 of water. 100 grains of the cryftals contain 33, 3 of acid, 50 of alkali, and 16, 7 of water. B.

water

water, of boiling water $2\frac{13}{17}$. The tafte, falt.—It fuffers neither deliquefcence nor fpontaneous calcination; it decrepitates in the fire, then flows.

The form cubic.

Vitriolated Lime; vulgo Gypfum.

(q) 100 parts contain 32 of pure lime, 46 of vitriolic acid, and 22 of water. One part requires of water at a moderate heat 500, of boiling water 450. The tafte earthy, fcarcely fenfible. It fplits in the fire; and in a very intenfe heat it fufes.

The form fpathaceous or octaedral; the two oppofite apices deeply truncated, fo as to refemble a table with a cuneiform margin.

Vitriolated Magnefia; vulgo Sal catharticus amarus—Epfom Salt.

(r) 100 parts contain 19 of pure magnefia, 33 of vitriolic acid, and 48 of water. One part requires 1 of water at a moderate heat, of boiling water fcarce $\frac{2}{3}$. The tafte

(q) The proportion of ingredients in natural gypfum varies, but of artificial 100 grains are eftimated, by Mr. Kirwan, to contain 32 of earth, 29, 44 of acid, and 38, 56 of water; when well dried it lofes about 24 of water, and therefore contains 42 of earth, 39 of acid, and 19 of water, per cent. B.

(r) 100 grains, perfectly dry, contain 45, 67 of mere vitriolic acid, 36, 54 of pure earth, and 17, 83 of water: in cryftals they contain 23, 75 of acid, 19 of earth, and 57, 25 of water. B.

N   exceffively

exceffively bitter, and fomewhat cold; it fuffers fpontaneous calcination in heat; in the fire it foams, grows dry, and fufes.

The form prifmatic, tetragonal, with pyramidal quadrangular apices.

Vitriolated Clay; vulgo *Alum.*

(*s*) 100 parts contain 18 of clay, 38 of vitriolic acid, and 44 of water; 1 part requires 30 of water in a moderate heat, of boiling water $\frac{3}{4}$. The tafte fweetifh, aftringent; it fuffers neither deliquefcence nor calcination; in the fire it foams, dries, and grows hard.

The form octaedral.

Nitrated Lime.

(*t*) 100 parts, well dried, contain 32 of pure lime; the water is not eafily afcertained, as a part of the acid is alfo expelled by calcination; it is probable that it amounts to 25 at leaft, and if fo, the acid will be 43: it deliquefces. The tafte extremely bitter and acrid; alcohol diffolves it, and by ebullition takes up its own weight: it cannot be reduced to the form of permanent cryftals.

(*s*) 100 grains perfectly contain 42, 74 of acid, 32, 14 of earth, and 25, 02 of water; in cryftals they contain 23, 94 of acid, 18 of earth, and 58, 06 of water. B.
(*t*) 100 grains, carefully dried, contain 33, 28 of acid, 32 of earth, and 34, 72 of water. B.

Nitrated

Nitrated Magnesia.

(*v*) 100 parts, well exsiccated, contain 27 of pure magnesia; setting down the water at 30, which in this case it rather seems to exceed, the acid will amount to 43: it deliquesces, yet may be obtained in the form of oblique, truncated, tetragonal, prismatic crystals; but they soon again deliquiate: the taste, extremely bitter, acrid: 1 part in a moderate heat requires, for solution, 9 parts of alcohol.

Salited Lime; vulgo Fixed Sal Ammoniac.

(*u*) 100 parts, well exsiccated, contain 44 of pure lime; supposing the water to be 25, the marine acid will be 31: it deliquesces, and cannot be reduced to permanent crystals. The taste extremely bitter: boiling spirit of wine dissolves its own weight of this salt.

Salited Magnesia.

(*w*) 100 parts, well exsiccated, contain 41 of pure magnesia; supposing the water to be

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(*v*) 100 grains, well dried, contain 35, 64 of acid, 27 of pure earth, and 37, 36 of water. B.

(*u*) 100 grains, well dried, contain 42, 56 of acid, 38 of earth, and 19, 44 of water. B.

(*w*) Of this salt Mr. Kirwan affirms, that it cannot be tolerably dried, without losing much of its acid, together with the water. B.

25, the marine acid will be 34; in deli-
quefcing it attracts 0,66 of water: 1 part in
a moderate heat requires 5 parts of alcohol:
The tafte extremely bitter.

(*x*) *Vitriolated Copper* ; vulgo *blue Vitriol.*

100 parts, cryftallized, contain 26 of
copper, 46 of vitriolic acid, and 28 of
water. The tafte acefcent, æruginous, cauf-
tic ; it calcines in heat: 1 part, in a mo-
derate heat, requires nearly 4 of water, but
of boiling water much lefs.

The figure compreffed, hexagonal, prif-
matic, obliquely and parallelly truncated on
both fides.

Vitriolated Iron ; vulgo *green Vitriol.*

(*y*) 100 parts contain 23 of iron, 39 of vi-
triolic acid, and 38 of water : in moderate
heat, 1 part requires 6 of water, of boiling
water $\frac{3}{4}$: in heat it fplits into a yellow
powder, in the fire, into a ferruginous
powder. The tafte acefcent, ftyptic, cauf-
tic.

The form, fpathaceous : when dephlogif-
ticated it depofits a portion of calcined

(*x*) 100 grains contain 27 of copper, 30 of acid, and
43 of water ; of which it lofes about 28 by evaporation,
or flight calcination.   B.

(*y*) 100 grains of this falt, in cryftals, contain 25 of
iron, 20 of real acid, and 55 of water.   B.

iron ;

iron; the ferruginous deliquefcent refiduum
is readily taken up by fpirit of wine.

Vitriolated Zinc ; vulgo *white Vitriol.*

(z) 100 parts contain 20 of zinc, 40 of
vitriolic acid, and 40 of water; in a mo-
derate heat, 1 part requires more than 2 of
water, but much lefs of boiling water.
The tafte acefcent, aftringent, cauftic.

The form, tetragonal prifmatic, termi-
nated by tetragonal pyramidal apices.

The advantage of knowing the proportion
of the conftituent principles is fignal and
extenfive;—thus, for example, fuppofe the
weight of the magnefia precipitated (B, 3)
to be equal m, then $\frac{33}{19} : \frac{45}{100}$ m = quantity
of vitriolic acid neceffary for faturating it ;
and $\frac{45}{19}$ m = vitriolated magnefia arifing
from thence — $\frac{33}{27} : \frac{45}{19}$ m, indicates the
weight of that vitriolated mineral alkali,
which is produced by precipitating the vi-
triolated magnefia by means of mineral al-
kali — $\frac{15}{27} : \frac{33}{19} : \frac{45}{100}$ m = the pure mineral
alkali neceffary for that precipitation ; and
$\frac{45}{20} : \frac{15}{27} : \frac{33}{19}$ m = the aerated alkali neceffary
for the fame purpofe. In the prefent cafe
m is given, and hence all the formulæ are
eafily determined. In like manner, on other

(z) 100 grains contain 20 of zinc, 22 of acid, and 58
of water.   B.

occafions, the caufes are found fo connected, that one phænomenon being given, many others are immediately fuggefted.

§ XII. *Analyfis is to be confirmed by Synthefis.*

When, by the experiments above propofed and defcribed, the feveral heterogeneous matters are determined, as to quantity and quality, and reduced by accurate analyfis to perfect certainty, nothing remains but to unite with pure water all the feparated matters in due proportion : if then the water, thus treated, exactly and perfectly refembles the water which has been examined, it muft afford an irrefragable argument that the analyfis has been properly conducted.

It is indeed but rarely neceffary to examine all waters with the extreme accuracy above defcribed ; but as the queftion was concerning the art of examining waters in general, no circumftance which has any relation to the fubject could properly be omitted, as all fuch may, in certain cafes, be ufeful, nay altogether neceffary.

§ XIII. *The Selection and Correction of Waters.*

Waters, with refpect to their ufe, may be divided into four claffes ; 1ft, thofe which may without difficulty be applied to daily ufe,

ufe, fuch are, good fountain, river, and lake waters: 2d, thofe which may indeed be ufed, but yet are attended with certain inconveniences, unlefs previoufly purified by fome means or other; to this clafs belong hard waters as they are called, and ftagnant waters, which have not fufficient motion: 3d, thofe which, on account of their contents, cannot be daily employed for the purpofes of life, but are ufed at certain times, and under certain regulations, againft infirmities and difeafes; fuch are the medicated waters: finally, 4th, thofe which, on account of the nature and quantity of their heterogeneous matters, are feldom or never ufed internally, but neverthelefs may in other refpects be extremely ufeful.

(A) It is unneceffary to beftow much labour upon the firft clafs, as daily experience evinces it to be harmlefs, and therefore not to require any correction. In proportion as water is rendered lefs turbid by acid of fugar, fixed alkali, or folution of filver, it is the more pure, and with the greater juftice referred to the firft clafs.

(B) The fecond clafs is rendered very turbid, by folution of fugar, or of fixed alkaline falt, and is confidered as the more impure in proportion to the quantity of precipitate.—Thefe waters are auftere, with a ftyptic difagreeable earthy tafte; they are apt to occafion obftructions; and a long continued ufe of them appears to be unfafe.

Thefe

These are much less fit for obtaining extracts from solid substances than the former class, and are therefore much less efficacious in brewing, in distilling, in preparing decoction of coffea, or infusion of tea, and many others; — for the washing of linen, these waters are more or less unfit, partly because they do not easily dissolve the impurities, partly because they decompose the soap, and render it unfit for the purpose. Hard waters, for the reasons above-mentioned, are totally useless in the bleaching of linen; they are also unfit for boiling pease, beans, and other pulse, as they neither macerate nor make them soft—the same is observed of old and hard flesh.

For the purposes of preparing hemp and flax by putrefaction, these waters are the less useful, as it is certain that they possess an antiseptic power; hence substances immersed in them preserve their strength and texture longer than they would do in better water; this circumstance affords a hint for trying whether these waters may not be usefully employed in long voyages, as they can, upon occasion, be easily made fit for use. Tin, in general, grows black with waters of this sort; they have been thought, by some persons, to be unfit for the watering of plants, but, as far as can be conjectured, they should be, in this intention, not only harmless, but singularly useful.

Waters endued with these properties are

called

called hard, and in such waters their effects are chiefly produced by an abforbent earth, united with an acid : if the aerial acid be the menftruum, boiling alone is fuffi-cient to correct the water. As this fubtile acid is expelled by heat, the earth which had been fufpended by it is no longer foluble in the water, and therefore precipitates, and all the minute particles attach themfelves to the inequalities of the fubftances they meet with, and adhere firmly ; hence it is, that tea-kettles are generally in a fhort time co-vered with a cruft of abforbent earth; and hence too it happens that the furface of pulfe is obftructed, fo that the water can-not penetrate them. The hardnefs of waters which depends upon this circumftance is of little confequence, as it may be corrected fimply, by boiling and cooling : but, in or-der to make it agreeable to the palate after the depofition of the calcareous matter, it muft be expofed to the open air, in broad fhallow veffels, by which it recovers from the atmofphere a portion of the aerial acid.

But if the abforbent earth be fufpended by means of any other acid, it is not fo eafily feparated ; and it is then particularly that it occafions many of the above-men-tioned inconveniences. The decompofi-tion of the foap takes place, becaufe the al-kali unites more willingly to the mineral acid of the middle earthy falt, than to the

oil,

oil, which therefore is expelled, and being insoluble by itself, is collected at the surface of the water in the form of drops or of a floating membrane.

The other effects are occasioned either by the middle salt itself, or take place from hence, that during the boiling, a part of the menstruum flies off, upon which the deserted base closely attaches itself to such bodies as it meets with. This dissipation readily happens to the nitrous acid, whether united with lime or magnesia, as also to the marine acid, when united with magnesia.

This species of hardness cannot be corrected by boiling alone, but may be removed by a fixed alkali, which precipitates the earthy base. For this purpose let a solution of pot-ashes, or any other alkaline salt, be poured into the water so long as it occasions any turbidness : after the precipitate has fallen to the bottom, it must be tried whether any turbidness is occasioned by the addition of more alkali ; when no more is found to fall, we may easily determine what quantity of alkaline salt any given water requires, by weighing the alkali and its solution, previous to the experiment. Finally, let the water, thus purified, be decanted off from the sediment, or, if necessary, filtered.

Stagnant waters are liable to corruption in warm weather, and afford lodgment to

millions

millions of infects. This inconvenience is
obviated in the fouthern parts of Europe, by
a fort of fandy ftone, called filters. The
water to be ufed for the preparation of food,
or for drink, is made to pafs through thefe
filters; and is thus freed from all fuch he-
terogeneous matters as are not united with
it in the way of folution.

(c) The cold medicated waters, which
poffefs peculiar power and efficacy, contain a
much larger quantity of aerial acid than the
common waters; and in general their excel-
lence is chiefly derived from the quantity of
their fubtile acid; however, as they are fel-
dom or never without a mixture of other fa-
line fubftances, it is by thefe that their pe-
culiar effects are fpecifically determined :
for, though the Seltzer and Pyrmont wa-
ters contain a large proportion of the aerial
acid, no one eftimates their efficacy by the
quantity of aerial acid, it being rather de-
pendent upon groffer falts; though thefe lat-
ter are certainly vivified by this true mineral
fpirit, and from it receive a more active and
penetrating power.—The method of deter-
mining the quantity of this volatile acid
contained in waters has been explained
(VIII. A, B).

Cold medicated waters in general may be
divided into fuch as are impregnated with
iron, and fuch as are deftitute of that
metal; and hence arifes a confiderable dif-
ference with refpect to their ufe; befides,

7   there

there are many chalybeate waters which
contain iron, either totally or partially dif-
folved in vitriolic acid : fuch waters, when
only moderately impregnated, may, in fome
cafes be fuccefsfully ufed, but are for the
moft part improper, and fometimes highly
pernicious ; therefore, as the number of
chalybeate fprings is very great, it is of
much confequence to be able to diftinguifh
the good from the bad, the wholefome from
the noxious : it would be extremely ad-
vantageous to eftablifh certain characteriftic
marks, by means of which, without any ar-
tificial apparatus, without any operofe ex-
periment, and without a knowledge of chy-
miftry, we may in any cafe readily difcover
whether a chalybeate water may be fafely
ufed or not.—The following obfervations
will be found particularly ufeful for that
purpofe : —

Let about half a kanne of the water to be
examined boil vehemently for about a
quarter of an hour, in a ftone veffel ; let it
then be removed from the fire, and cooled ;
this being done, let about $\frac{1}{8}$ of the water be
poured out into a glafs veffel ; and add 2,
4, or at moft 6, drops of tincture of galls
(VII. D). If, now, no purple or violet tinge
is produced—if no blacknefs appears, even
after ftanding for fome hours, this is a fa-
vourable fign, affording fufficient proof that
the fpring is of a good quality, and truly aci-
dulous : but if the vitriolic acid be the
menftruum,

menftruum, it depofits an ochre upon boiling, without lofing its power on aftringents.

There occurs alfo a third cafe, namely, where the iron is partly diffolved by aerial acid, partly by vitriolic acid : fuppofing then the quantity of the latter to be fo fmall, that when the former is feparated by boiling, the water has no fenfible effect upon tincture of galls; there will in this cafe, it is true, be prefent a vitriol of iron, but in far lefs proportion than that of three grains to a kanne (VII. D), fo that it is free from any noxious quality, and even this minute portion may, if neceffary, be eafily made vifible; for let the water be boiled until only a twentieth part remains, add then a few drops of tincture of galls, and it will inftantly be tinged.

It is thus that the hot waters, which are remarkable for efficacy, abound either in atmofpheric acid, as the Caroline waters in Bohemia, or with hepatic vapour, as thofe of Aix. Waters containing the groffer falts, without any elaftic vapour, without a vivifying principle, are as it were dead; and, if not entirely inert, are at leaft heavy, and of fmall virtue.

In general the various medicated waters, both hot and cold, contain fixed principles in a proportion fo fmall that they may be rendered fit for domeftic ufes, only by boiling

and

and cooling, if fcarcity of other water fhould render that procefs neceffary.

If a water be rendered unfit for ufe by the admixture of a fmall quantity of metallic falt, this may be removed by a fixed alkali in the manner defcribed (B) ; but if it be in large quantity, this inconvenience is occafioned by the correcting it ; namely, that another, though a more innoxious falt, fucceeds to the firft. Thus, when a vitriol is precipitated, there arifes a vitriolated vegetable alkali, which, though of a weaker tafte, yet occafions a degree of bitternefs, greater or lefs, according to its quantity ; however, this falt does not produce any noxious effects in the human body, but is reputed a gentle purgative, nor does it prevent the water from being converted to a great number of ufes ; hence it appears that a water contaminated, even by a vitriol, may, in cafes of urgent neceffity, afford an ufeful fupply, by means of the remedy juft defcribed.

(D) Waters which contain a large quantity of any neutral falt, fuch as vitriolated mineral alkali, common falt, &c. or any noxious metallic falt, fuch as green, blue, or white vitriol, are unfit both for internal and domeftic ufes, though the fubftances with which fuch waters are loaded may be advantageoufly collected, and applied to other ufes.

Sea-

Sea-water has not only the ſtrong taſte of common ſalt, and the bitter one of ſalited magneſia, but occaſions a very ſingular nauſea, which is frequently attended with vomiting.   This nauſeous ingredient is not to be found at all, or but very little, in ſea-water taken up at the depth of ſixty fathom, as experiments made upon water taken up at that depth evidently ſhew; the reaſon perhaps is, that the immenſe quantity of fiſh, worms, and other animals, which inhabit in the ocean, dying, are gradually carried up to the ſurface, and there, by the aſſiſtance of the air, are deſtroyed by putrefaction (at leaſt this is the caſe with ſuch parts of them as are ſoluble in water); and this putrefactive proceſs is much aſſiſted by the ſalt which, at the ſurface, is preſent in preciſely the quantity neceſſary to promote that operation.

To render ſea-water fit for the uſes of mariners is an art long wiſhed for, and of the higheſt moment.   That which is taken up at the depth of ſixty fathoms, or more, on account of its extreme ſaltneſs, is indeed unfit for allaying thirſt; but, when mixed with an equal quantity of freſh water, may, beyond doubt, be very uſefully applied to the preparation of food, as it thereby ſaves one half of the ſtock of freſh water.

That water which is found at the ſurface can only be rendered fit for drink by diſtillation, as recent experiments have ſhewn.

Many.

Many different forts of apparatus have been contrived for this purpofe; and even the vapour arifing from the veffels in which food is prepared has been employed. The moft fuitable apparatus for this purpofe is fuch as will at once yield the greateft poffible quantity of water, and require the fmalleft quantity of fuel: but this is not to the prefent purpofe; fuffice it to fay, that fea-water diftilled, and then expofed to the air, becomes agreeable and wholefome;—that which firft comes over fhould be thrown away, if it contains any thing putrid. Some part of the marine acid will be difengaged by violent and long continued boiling—but this inconvenience may be eafily avoided, by adding at the beginning a little pot-afhes, which decompofes the falited magnefia.

DISSER-

DISSERTATION III.

ON THE

WATERS OF UPSAL.

Tales funt aquæ, quales terra per quam fluunt.
<div align="right">PLIN.</div>

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§ I. *Good Springs are to be met with in great plenty, at Upfal.*

WHOLESOME water, in fufficient plenty, is one of the greatest advantages any place can poffefs, and the moft likely to induce people to fettle in it; becaufe water is among the moft indifpenfable neceffaries, not only for men and animals cooped up in a fmall fpace, but likewife for a fingle family, however fmall it may be; fo that fcarcity, or the bad quality of water, expofes them to numberlefs inconveniences. If any city in Sweden may boaft of being fortunate in this refpect, it is certainly Up-

<div align="center">O</div>
<div align="right">fal,</div>

fal, for, befides the river which runs through it, there are feveral excellent fprings, and very good wells. As it is important to know the fubftances contained in them, I will relate fome experiments made with this view; but, to avoid too tedious a detail, I fhall only fpeak of the moft remarkable, fuch as are common to the whole city, over-looking the others, of which each ferves only a fingle family.—I fhall then confine myfelf to the examination of the fix fol-lowing.

1. The fpring belonging to the citadel, rifes at the bottom of the hill on which that fortrefs is built; this eminence confifts of fand; its elevation is of 100 Swedifh feet above the level of the river; it extends on each fide to a great diftance from the city; it has various heights and windings, being fometimes low, and as it were creeping, at others, rifing to a confiderable height. This hill fupplies all the water, not only of the fpring in the citadel, but of the other fprings and wells to the fouth of the river, except that mentioned in the 6th §. Frefh ones may eafily be found, by finking at its foot.

This fpring was almoft forfaken till with-in thefe few years; and as it was expofed, it became gradually full of impurities, which obftructed its veins; fo that, in Fe-bruary 1767, it was almoft dry—much lefs rain than ufual had fallen the preceding au-tumn.

tumn. It however again made its appearance; but the ftrongeft branches opened another iffue nearer the river, where a ftone bafon was made for it, with the addition of a roof, and where it furnifhes water of a quality fuperior to all the other fprings.

2. The fpring that rifes near the mill of the Univerfity was defended by walls during the whole of the 17th century; but they were deftroyed in 1702, at the time of the fire, which confumed great part of the city. As it was neglected afterwards, it was obliged to bear its waters to another place, where it was again furrounded by ftone work in 1759. As it is very near the banks of the river, it is every fpring and autumn overflowed by the floods during fome days.—I fhall call it the mill-fpring, though it is fometimes called St. Eric's fountain.

3. The Sandvik fpring, which takes its name from a little hamlet in the neighbourhood, is fituated at the diftance of about $\frac{1}{8}$ of a mile from the city;—it rifes near the river.

In 1776 the king built a ftill-houfe for the diftillation of corn fpirit, for which it furnifhes a very good water in fufficient plenty: it is fo dammed up, as to form a kind of lake.

4. The well which has obtained the name of Odin, and which yet is not of fo high antiquity, is fituated near the college of Guftavus; it is deep, and enclofed with

O 2   ftones,

ſtones, but there is no bed to convey away
the water, and it is therefore neceſſary to
pump it.

5. The well, which bears the name of
Luth, formerly profeſſor of divinity, is ſi-
tuated further to the north; it is encloſed
with ſtone; and they who chuſe to uſe it,
are obliged to raiſe it.

6. The draw-well *(puteus tractorius)* ſo
named, for I know not what reaſon, is the
only one on the other ſide of the river; it is
open to every body, neverthelefs is ſeldom
uſed, unleſs for ſome mean purpoſe.

§ 11. *A Compariſon of the Phyſical Qualities
of the Upſal Waters.*

(A) The water of the ſprings is as
limpid as cryſtal; the wells are little in-
ferior, except the 6th, which has a ſlight
opal tinge, but leſs perceptible than the
river water.

(B) Good water ſhould be taſteleſs: the
ſpring in the citadel excels in this reſpect;
next follow thoſe of Sandvik, and the
mill; but theſe waters, though excellent,
impreſs, upon a delicate and practiſed palate,
ſomewhat of an earthy favour. The water
of Odin's and Luth's wells is agreeable, but
rather leſs briſk, becauſe it is almoſt ſtag-
nant. The water of the draw-well, being
more impregnated with earth, is by no
means agreeable to the taſte.

(c) The

(c) The temperature of the fprings is at 6 during almoft the whole year; in the dog-days, it fcarce increafes 2° or 3°: that of the wells is generally at 7. The water of the river follows the changes of the atmofphere.

(D) There is a fmall difference in the fpecific gravity — the river water is the lighteft of all; next, that of the fpring in the citadel. Their weight is as follows, at a temperature of 15° (a):

Diftilled water — —	10,000
Pure fnow-water — —	$10,000\frac{1}{2}$
Water of the river — —	$10,001\frac{1}{2}$
of the fpring in the citadel	10,002
of the mill-fpring — —	10,002
of the Sandvik fpring —	10,002
of Odin's well — —	10,003
of Luth's well — —	10,003
of the draw-well — —	10,012

(E) The water of the fprings and wells is rather more copious in very wet feafons, but does not diminifh in long droughts. The mill-fpring affords 3,900 kannes every hour, or $3\frac{9}{10}$ cubic feet; that of the citadel lefs, but the Sandvik fpring much more.

(a) 6 = 42 or 43, 7 = 44 or 45, and 15 = 59 of F. B.

§ III. *The Principles of these Waters, collected by Evaporation.*

(A) All these waters deposit, during ebullition, a grey powder, which in time forms a crust on the internal surface of the vessels. As most of them afford only a small deposition, it is not necessary to collect it, as it separates: it is better to continue the evaporation to dryness. Having evaporated, at the beginning of June, after a long continuance of dry weather, 6 kannes of each of these waters, I found the quantity of residuum to be per kanne as follows:

	grains.
The river water -	8
That of the mill-spring - -	9½
of the citadel - -	10
of the Sandvik spring - -	10
of Odin's well - -	12
of Luth's well - -	12½
of the draw-well - -	51

(B) In order to separate the saline from the earthy part, the several residua should be washed in distilled water, dried, and weighed; then some marine acid should be poured on the earthy matter, which, in the present instance, produces a violent effervescence, and dissolves the greater part; what is not dissolved by the acids cannot be fused by

by itfelf upon coals excited by the blow-
pipe, when it has been well wafhed ; it re-
fifts fufion after the addition of microcof-
mic falt ; borax produces this effect, but
very flowly ; mineral alkali, fufed in a filver
fpoon or ladle, attacks it with effervefcence,
and completely diffolves it ; the refidua of
the river water, and that of the draw-well,
muft be excepted, for a fmall portion of
them remains infoluble (b) : this, there-
fore, is filiceous earth, which, although it
is fpecifically heavier than water, feems to
have been fufpended by means of its tenui-
ty ; for it is poffible that, by being pulve-
rized, an heavier fubftance may be made to
acquire fo much furface, that the friction of
the water, which muft be overcome before
it can fubfide, may form an equilibrium to
the excefs of its weight. Though quartz is
of a truly faline nature (c), yet I can fcarce
believe that it is diffolved in fo large quan-
tity ; I muft not, however, omit to remark,
that it cannot be feparated from our waters,
either by filtration or reft : it is found
among the aerated calcareous earth adhering
to tea-kettles.

The folution in the marine acid affords
only calcareous earth on addition of alkali ;

(b) In the fecond volume of this Collection will be
found an Effay on the Blow-pipe, and the way to
ufe it.

(c) Here the author refers to the 12th Differtation of
the firft volume, but there are only 11. It is the 2d of
vol. ii.

O 4 wherefore

wherefore our waters contain only aerated calcareous earth, and a little quartz; but in different quantities, as we ſhall ſoon ſee. The river water, and that of the draw-well, are beſides charged with a little clay, which we ſaid that the alkali was incapable of diſ-ſolving by means of heat.

(c) The diſtilled water which has been poured on the reſiduum to diſſolve the ſaline part, furniſhes, by ſpontaneous evaporation, common ſalt, ſalited lime, and vitriolated foſſil alkali: the calcareous ſea-ſalt may be ſeparated by highly rectified ſpirit of wine (d). The laſt ley, when concentrated by evaporation, affords very often a little mineral alkali, which is of a dark red; but the phlogiſticated alkali does not give a blue precipitate: the water of the draw-well affords moreover a few ſmall priſms of ni-tre, which may be known by their detona-tion on charcoal; and, inſtead of Glauber's ſalt, a little ſelenite.

(D) In order to learn the nature of the elaſtic fluid contained in theſe waters, I boiled a certain quantity of each in a glaſs retort, of which the end of the neck was bent upwards, and introduced under a little phial inverted, and full of mercury. The fluid thus obtained is partly abſorbed by water, and conſequently muſt be aerial acid; the remainder is pure air, fit for the

(d) See the foregoing Diſſertation, § x. A, § xi. A.

ſupport

fupport of ignition and refpiration. It is obvious, that the quantity of common air remaining in the upper part, and the neck of the retort, before the vapours begin to rife, fhould be deducted.

(E) Nearly the fame fubftances are to be found in all thefe waters ; but the quantities differ.—The following are what they contain per kanne :—

	grains.
The river water contains of aerated calcareous earth - -	2
That of the citadel-fpring - -	5
of the mill-fpring - -	$5\frac{1}{2}$
of Sandvik fpring - -	$5\frac{1}{2}$
of Odin's well - -	$5\frac{1}{2}$
of Luth's well - -	6
of the draw-well - -	21
The river water contains of filiceous powder - -	$\frac{1}{2}$
of the citadel-fpring - -	$\frac{1}{2}$
of the mill-fpring - -	$\frac{1}{2}$
of Sandvik fpring - -	$\frac{1}{2}$
of Odin's well - -	$\frac{1}{2}$
of Luth's well - -	$\frac{1}{2}$
of the draw-well - -	1
The river water contains of clay - -	$\frac{1}{2}$
The draw-well - -	1
The others - -	0
The river water contains of common falt	$1\frac{1}{2}$
The citadel-fpring - -	$3\frac{1}{2}$
The mill-fpring - -	$2\frac{1}{4}$
Sandvik fpring - -	$2\frac{1}{4}$

Odin's

grains.

Odin's well - - $3\frac{1}{4}$
Luth's well - - - $3\frac{1}{2}$
The draw-well - - $18\frac{1}{2}$
The river-water contains of falited lime $\frac{1}{4}$
The citadel fpring - - $\frac{1}{2}$
The mill-fpring - - $\frac{1}{2}$
The Sandvik fpring - - $\frac{1}{2}$
Odin's well - - - $\frac{1}{2}$
Luth's well - - $\frac{1}{2}$
The draw-well - - 1
The river-water contains of vitriolated tartar - - - - 0
The citadel fpring - - $\frac{1}{4}$
The mill-fpring - - $\frac{1}{4}$
Sandvik fpring - - $\frac{1}{4}$
Odin's well - - - $\frac{1}{2}$
Luth's well - - - $\frac{1}{2}$
The draw-well - - 0
The water of the draw-well contains of felenite - - - $8\frac{1}{4}$
The reft - - 0
The river water contains of aerated foffil alkali - - - 0
The citadel fpring - - $\frac{1}{4}$
The mill-fpring - - $\frac{1}{4}$
Sandvik fpring - - $\frac{1}{4}$
Odin's well - - - $1\frac{1}{2}$
Luth's well - - $1\frac{1}{2}$
The draw-well - - 0
The river-water contains of extractive mucilage - - - $\frac{1}{4}$
The draw well - - $\frac{1}{8}$
The others nearly - - 0

The

The water of the draw-well contains of grains.

    nitre   -   -   - $\frac{1}{2}$

      The others   -   -   -   o

All thefe waters contain about the fame quantity of air, *viz.* 6 cubic inches; of which nearly 4 are aerial acid, the reft pure air, which is carefully to be diftinguifhed from common air (*e*).

The quantities juft laid down vary a little: they increafe or diminifh in the different feafons, according to the quantity of rain and fnow, and from other circumftances. It is poffible, nay, it does undoubtedly come to pafs, that the proportions undergo fome change in the courfe of feveral years; for at firft the water diffolves with facility all the foluble fubftances of the ftrata over which it paffes; and after it has fucceffively carried them away, it meets with no more, at leaft the quantity is diminifhed: befides, thefe fubterraneous canals themfelves are liable to various changes. In one place the old ones are ftopped up, in another new ones are opened: now, fince the particles of the ftrata traverfed by the waters are not conftantly of the fame nature, it cannot appear ftrange that they fhould partake of thefe varieties.

(*e*) See above, Diff. I. § XXII.

(F) We

(F) We have already obferved, that the filiceous earth was fufpended in our waters, on account of the extent of furface arifing from the tenuity of its particles : the fame remark may be applied to the greater part of the aerated calcareous earth, which feparates along with the filex during ebullition. In reality the water, when rarefied by the heat, lofes fo much of its fpecific gravity that the earths are precipitated : the increafed mobility of the particles of the water facilitates this feparation. The calcareous earth held in folution by the aerial acid ftill further contributes to the production of this effect; becaufe, as the heat volatilizes the folvent, it joins the fubftances which are only diffufed, and enlarges their molecules. It is now eafy to conceive why teakettles come to be covered with a calcareous cruft, of which the quintal contains about 3 or 4 pounds of particles of quartz.

A kanne of water, completely aerated, is capable of diffolving 27 grains of aerated calcareous earth (ƒ); wherefore our waters, which contain in that quantity only four cubic inches of this acid, will diffolve little more than a grain. It will perhaps appear ftrange that the particles which are fufpended in a fluid, only on account of their fmallnefs, fhould not impair its tranfparency : but, in the firft place, I have remarked, that the

(ƒ) See Diff. I. § 11.

water

water of the draw - well, which contains
moſt earth, is a little opal coloured; on the
other hand it ſhould be conſidered, that par-
ticles of ſufficient tenuity to.paſs through
the filter, and to remain ſuſpended in wa-
ter by friction alone, muſt neceſſarily be
tranſparent, at leaſt as long as they are ſur-
rounded by water.

§ iv. *Effects produced by Precipitants on the Waters of Upſal.*

(A) Theſe waters ſcarce heighten paper
coloured blue by turnſole; they give a
ſlight ſhade of blue to paper made red by
Brazil-wood; they do not at all alter paper
tinged by turmeric. The cauſes of theſe
changes have been aſſigned above (*g*).

(B) Spirituous tincture of galls ſhews no
veſtige of iron, any more than the phlogiſ-
ticated alkali.

(C) The mineral acids produce no per-
ceptible change. If a little of the cryſtal-
lized acid of ſugar be thrown into them, it
generally forms white ſtreaks as it paſſes
through .the liquor, and a white powder,
which is real ſaccharated calcareous earth,
collects round it at the bottom of the veſſel.
Theſe phænomena are but faintly exhibited
by the river water; they are more percep-

(g) See Diſſ. II. § vii.

tible

tible in that of the springs; and very evi-
dent in those of the wells, especially of the
draw-well. The saccharine acid also occa-
sions a small precipitate in snow-water, but
it is not visible for some hours (*h*). This
acid scarce makes our waters turbid after
boiling, especially the spring-waters, which
deposit most of their earth during the
boiling.

(D) The fixed alkalis precipitate a white
earth, which on examination is found to be
real calcareous earth. A copious precipita-
tion takes place immediately in the draw-
well water; in the rest it is slower, and far
less considerable. The water of the draw-
well is scarce made turbid, after boiling, by
addition of alkali.

(E) Lime-water turns white instantly,
and a calcareous precipitate is formed; this
is owing to the aerial acid which combines
with the pure calcareous earth, and carries
down with it the earth which was held in
solution by the excess of this acid, and which
is then deprived of its solvent (*i*).

If these waters be made to boil briskly,
and a larger quantity of lime-water be then
added, a slight turbid appearance is per-
ceived, which announces the obstinate ad-
herence of the last portions of aerial acid.

(*h*) See below, Diff. VIII. § vi.
(*i*) See Diff. I. § xi.

(F) Salited

(F) Salited ponderous earth in the fpace of 24 hours caufes no alteration in the water of the river; a very flight one in that of the fprings; and a much more perceptible one in that of the wells, particularly of the draw-well, from which it precipitates a white powder; this clearly announces the prefence of the vitriolic acid (*k*).

(G) Salited lime produces no change in thefe waters; they indeed contain no fubftance capable of decompofing it.

(H) If a piece of alum be thrown into any of thefe waters, it is decompofed as it diffolves: the aerated calcareous earth attracts the vitriolic acid; and the argillaceous bafis, left alone, forms, as ufual, a ftratum parallel to the bottom of the veffel.

(I) The folution of filver clouds all thefe waters;—it fcarce affects fnow-water.

(K) Nitrated mercury, made without heat, occafions a white precipitate in them; that made with the aid of heat occafions a yellow precipitate, which, in the water of the draw-well, is very copious. Snow-water is fcarce rendered turbid by the former of thefe preparations, and very fenfibly by the latter.

(L) Corrofive fublimate fometimes occafions a flight precipitate, of a white colour,

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(*k*) See Differtation II. § VII. and the Effay already quoted on the Elective Attractions.

which

5

which fhould perhaps be attributed to a little volatile alkali.

(M) Acetated lead inftantly renders thefe waters milky. The lead precipitated in the river-water is entirely foluble in diftilled vinegar; a fmall part of that precipitated in the water of the fprings remains infoluble in that menftruum; but it is vifible only when large quantities have been fubmitted to examination. More of the precipitate formed in the water of the wells refifts the action of vinegar, which attacks falited but not vitriolated lead.

(N) A piece of martial vitriol, thrown into thefe waters, occafions a precipitation of martial earth as it diffolves. If a few drops of the folution of this vitriol be poured into a fmall phial, containing about an ounce of water, and the precipitation be immediately made by a few drops of liquid vegetable alkali, the precipitate, which at firft is green, foon changes to a yellow co-lour, though the bottle is full, and well ftopped: this phænomenon indicates the prefence of pure air in our waters, which attracts the phlogifton of the precipitate. Let the fame operation be repeated on thefe waters immediately after boiling; if they are kept in well-clofed phials, the martial precipitate will preferve for whole years the green colour which it owes to the phlo-gifton.

(o) Soft

(o) Soft Venice foap, rubbed in our wa-
ters, produces a copious foam, except in that
of the draw-well, in which it lathers very
imperfectly : they all take up a portion of
the foap, which renders them milky ;—even
that of the draw-well does not recover of
itfelf its former tranfparency.

§ v. *On the Ufes for which thefe Waters are fit.*

From thefe obfervations we are enabled
to judge of the fuperior excellence of the
Upfal waters : that of the draw-well muft
be excepted ; but it may be corrected by
boiling, and would be much improved, if
it was oftener drawn, and lefs ftagnant ;
it is indeed not quite crude, fince it dif-
folves a little foap. If we overlook this
water, and that of the river, they are all
agreeable to the tafte, when they are drank
cold ; but the fpring belonging to the ci-
tadel has fome advantage over the others :
the waters of all the fprings, however, are
equally good to be drank hot. The river-
water is generally ufed for wafhing, for
boiling garden-ftuff, making coffea, beer,
and fpirit of corn, principally becaufe a
large quantity may be procured with lefs
trouble. The water of all the fprings, and
the two firft wells, would ferve equally

P   well,

well, and indeed, on fome occafions, would
be preferable ; for inftance, for the wafh-
ing of fine linen, for ftarching it, and
tinging it with a flight blue, by means of
turnfole—the water of the fprings fhould be
preferred, becaufe that of the river gives it
a reddifh hue.

DISSERTATION IV.

ON THE

ACIDULOUS SPRING

IN THE

PARISH OF DENMARK.

Justâ confeffione omnes terræ quoque vires aquarum funt
beneficii. Quapropter ante omnia ipfarum potehtiæ ex-
empla ponemus. Cunctas enim quis mortalium enu-
merare queat? PLIN.

---

§ 1. *Of medicinal Waters in general.*

PHyficians have two principal ways of
curing, or at leaft of alleviating, the
numberlefs maladies by which the human
frame is affailed. They either employ re-
medies of fuch efficacy as to produce an evi-
dent effect in the courfe of a few hours ; or
elfe they prefcribe a frequent repetition of
mild medicines in fmall dofes, of which the
action does not become fenfible till feveral
weeks, and fometimes till feveral months,
have elapfed : among the latter, mineral wa-
ters are juftly enumerated ; they effect fur-
prifing cures every day ; and fuch as could
not be expectedfrom any other mode of cure
hitherto difcovered. We are not to attri-

bute

bute thefe effects to fimple water, confidered
by itfelf; for, according to fuch a fuppofi-
tion, they would be produced in every place
alike, but to the fubftances mixed with it,
and diffolved in it, by which it is fharpen-
ed, and, as it were, armed with fuch efficacy.
Hence, in all ages, good phyficians, defirous
of eftablifhing the falutary art on a firm
foundation, have confidered it as a duty in-
cumbent upon them to fubmit to chymical
analyfis fuch waters as were famous for
the cure of any difeafe; and if this tafk had
been performed with proper exactnefs, we
fhould now be enabled to form a certain
judgment upon the ufe and virtues of all
mineral waters. When the compofition of
any medicine is perfectly underftood, and
its mode of operation has been carefully ob-
ferved on various occafions, the phyfician
has then fixed and clear notions concern-
ing its effects, which cannot fail of be-
coming highly ferviceable in future, when-
ever a mixture of the fame fubftances, in the
fame proportion, is difcovered: if fo necef-
fary a part of knowledge has not been hi-
therto acquired, it is becaufe the analyfis
of waters forms one of the moft difficult
problems in chymiftry. The fubftances
held in folution are of various kinds, and
always in very fmall quantity: not to men-
tion that feveral of thefe fubftances, and
thofe the moft important, have not been well
known till of late; and hence it happened,
that

that the moft accurate analyfes have fallen very far fhort of perfection.

Henceforward, let us rely on no analy-fis, until a mineral water, in every refpect refembling the natural water, has been re-compofed, with pure water and the fub-ftances that have been obtained.

§ 11. *Situation of the Spring at Denmark.*

The fpring which I propofe to examine with fome attention is fituated at the diftance of about three-quarters of a mile fouth-weft from Upfal, in the parifh of Denmark. In the neighbourhood feveral veins of mineral wa-ter have been difcovered, but four efpe-cially are in repute; they are very near to-gether, and rife in the meadow Wallby, of which the foil is argillaceous. Thefe aci-dulous fprings were difcovered in 1733, and frequented with great advantage; they were afterwards forfaken and neglected, for what reafon I know not, till the fpring of the prefent year (*a*). Then Ab. Scoderberg, a fkilful furgeon of the Upland regiment, caufed a proper refervoir, and the neceffary buildings, to be conftructed, a little nearer

(*a*) The celebrated G. J. Wallerius publifhed, thirty-fix years ago, a defcription of this fountain newly difcover-ed, in a work entitled, "Tankar om Danemarks Halfo-"brune." He mentions fome fortunate cures effected by them; but they have probably undergone great changes fince that time, as will appear from a comparifon of his defcription with that which I fhall give below.

the

the royal road than they were before. Laſt ſummer a great concourſe of people reſorted to theſe waters, and took them with bene-fit. This fountain lies in a plain between the ſouth and the weſt: there is an emi-nence ſituated at ſome diſtance, from which the ſprings probably derive their origin.

§ III. *Phyſical Qualities of this Fountain.*

The four veins afford much more than one hundred kannes of water every hour, which appears very limpid; but, when compared with that of the ſprings at the mill, or citadel, a conſiderable difference is perceived. When it is at reſt, or runs but ſlowly, its ſurface ſhews the ſeveral colours of the rainbow, and a depoſition of ochre is ſeen at the bottom. If the reſervoir has been kept long cloſed, a ſtrong hepatic ſmell is exhaled from it, which may alſo be per-ceived after ſhaking the water for a few moments in a corked bottle, and then ap-plying it to the noſe.

This water has a taſte of ink, but it is very ſoon found to be in a great meaſure de-ſtitute of that briſk and agreeable acid which makes the acidulous ſprings in repute ſo vo-latile and ſo efficacious.

The temperature is between (*b*) 9° and 10°.

The ſpecific gravity is to that of diſtilled water as 100,26, 10,000.

(*b*) 48 and 50. B.

§ IV. *The*

§ IV. *The Quantity of Aerial Acid.*

I have made many experiments to deter-
mine how much of that elastic which is pro-
perly called the aerial or atmospherical acid,
is contained in this acidulous spring.   One
part changes ten parts of the blue tincture
of turnsole to a very perceptible red ; how-
ever, four parts do not alter this tincture so
much as one part of the Spa water.

Agitation in a corked phial produces ra-
ther more bubbles in this water than in
that of common springs treated in the same
manner.   If what has been said above of its
taste be recollected, it will appear that there
is a deficiency of aerial acid ; as will be seen
still more clearly, if it be disengaged by
heat, and collected by means of quicksilver
(*c*) : in truth, it is scarce found to contain
seven cubic inches in a kanne ; whereas the
same quantity of Spa and Pyrmont waters,
as they are imported into Sweden, contain
the former near seven times, and the lat-
ter thirteen times as much.

§ V. *The Principles obtained by Evaporation.*

In order to obtain the fixed substances
which do not fly off at a boiling heat, I eva-
porated given quantities of this water in the
following manner :—after exposing it to the

(*c*) See Diss. II. § VIII.

P 4

fire

fire for four minutes, I fuffered it to cool. I then filtered it, and obtained a kind of ochre, amounting to 1¾ grain per kanne. As it is neceffary to adopt fome procefs for procuring an equal exficcation of the refidua before they are weighed, I expofe them for fifteen minutes to an heat of 100° (*d*). This term, which is that of boiling water, feemed the moft convenient, becaufe it may always be very eafily obtained.

The filters fhould be dried at this degree, and afterwards weighed, in order to eftimate what they contain. It is indeed impoffible to prevent fome very fubtile particles from paffing through; but it is ftill more difficult to feparate the fubftances completely which adhere to and penetrate white paper not alumed, which is proper for this purpofe. After thus weighing the fubftance, along with the filter, we have only to deduct the weight of the latter to find exactly that of the former; moreover, this mode of drying is more convenient, becaufe, after the filter and its contents have been left expofed to the air, it may be rolled up, and put into a glafs phial, and the boiling heat thus applied to it.

My aim, by this firft evaporation, was to learn, whether a little calcareous earth or magnefia was not held in folution by the aerial acid; for we have feen that they lofe, at this temperature, the excefs of that fluid ne-

(*d*) 212° of Fahrenheit, B.

ceffary

ceffary for their folution, when they preci-
pitate, and remain on the filter, along
with the ochre. In the prefent inftance
there was no obfervable veftige of them, and
the refiduum did not effervefce in the leaft
with the acids: I then continued the eva-
poration till the water was reduced to $\frac{1}{10}$;
and, after having filtered the liquor again,
the refiduum, when dried, amounted to 2 $\frac{3}{4}$
grains per kanne.—All the following num-
bers are to be referred to this meafure,
which I will mention no more, and which
ought always to be underftood, unlefs another
is particularly fpecified.—When the eva-
poration of the reft was finifhed, and it had
been dried, there remained 16 grains;
wherefore we have 20 $\frac{1}{2}$ grains for the fum
of the feveral refidua, of which we are now
to examine the nature.

§ VI. *This Water contains aerated vitriolated*
Iron.

The prefence of iron is known by the
ochre which it depofits, its tafte, the black
colour it ftrikes with aftringents, and the
blue colour produced by phlogifticated al-
kali. But it foon appears, that a very fmall
portion only of this metal is held in folu-
tion by the volatile acid; that the greater
part is combined with an heavier and a more
fixed acid, becaufe this water retains the
property of turning black with aftrin-

gents

gents (e), after having been long expofed to the open air, and even after boiling, to the laft drop; whence we may conclude that it is a vitriolic water, for if the iron was diffolved by the aerial acid only, it would be all precipitated by boiling. On the contrary, water impregnated with martial vitriol, kept in an open veffel, is continually depofiting fuccefive portions of ochre; becaufe, as the metallic bafis gives out its phlogifton to the air, which attracts it with great eagernefs, the acid can no longer hold the fame quantity as before in folution; for, as iron is more deprived of inflammable principle, it requires more acid for its diffolution, and heat promotes the diffipation of the phlogifton. In water containing a very fmall portion of vitriol of iron it may be fo far diminifhed by this means, that neither tincture of galls nor phlogifticated alkali produce any fenfible effect.

According to fome modern chymifts, whatever water gives a blue colour with phlogifticated alkali certainly contains green vitriol; but this opinion is refuted by experiment, for diftilled water, impreg-

(e) It fhould be obferved, that an excefs of tincture of galls may eafily miflead, becaufe common water, containing a little aerated calcareous earth, without an atom of iron, precipitates it. The precipitate is of a yellowifh white colour, and not perceptible at firft; if a little iron fhould be prefent, there will be a mixture of violet-coloured particles, and in two hours a greenifh tinge will appear.

nated

nated with aerated iron, affumes the fame
tinge, only a little more flowly; a circum-
ftance that will not furprize thofe who con-
fider the unequal ftrength of the two acids
with which the iron is combined : it is even
certain that vitriol of iron, completely fa-
turated, does not afford a fine Pruffian blue
fo fpeedily nor fo copioufly as that in which
there is excefs of acid; for the precipitate
of the latter fhews inftantly the fineft blue,
whilft that of the former has at firft a
blackifh or whitifh tinge.   In the prefent
inftance, the vitriolic acid is more clearly
detected by other proceffes :—the addition
of vinegar of lead produces fmall angular
grains, which are not attacked by vinegar;
befides, if the iron is precipitated by the
fixed vegetable alkali, a true vitriolated tar-
tar may be obtained by cryftallization. Now
this could never happen, if no vitriolic acid
was prefent to combine either with the lead
or the alkali.

It is poffible to determine the quantity of
iron, by the colour which the water receives
from the tincture of galls; by trying, with an
equal number of drops of the tincture,
equal quantities of water, more or lefs im-
pregnated with vitriol : when the fhade is
the fame, the bulk of water equal, and the
quantity of the aftringent principle the fame,
the quantities of iron muft needs be equal;
and, as the operator knows how much is
contained in the folution which he made, he
will

will alſo know the weight of that contained in the water which he is analyſing : this proceſs is not to be rejected with diſdain, but to be certain of the reſult requires a tedious exactneſs. Others, after waſhing the whole reſiduum in pure water, then drying and weighing it, pour one of the mineral acids upon it, and afterwards pour- ing off the acid, waſh what remains undiſ- ſolved, then dry and weigh it again, and from the diminution of weight collect that of the iron. This method is not a bad one, but care muſt be taken not to uſe too ſtrong an acid, not to add too much of it, and not to continue the digeſtion long ; for if there ſhould be any ſelenite in the reſiduum, as it is ſoluble in the acids, they may take up more or leſs of it, perhaps the whole, and the operation would not be exact ;—the ſureſt way is to precipitate all the iron with phlogiſticated alkali.

A kanne of this water furniſhes, by this proceſs, near 16 grains of precipitate, which contain about 14 grains of martial vitriol, as 100 of this ſalt in cryſtals afford 115 of Pruſſian blue : the ſmall quantity of iron diſſolved by the aerial acid muſt be deducted, but this ſcarce exceeds $\frac{1}{4}$ of a grain, for 100 cubic inches of this acid take up only 4 of iron (f).

(f) See Diſſertation I. § xiv.

§ vii. Of

§ VII. *Of the Selenite.*

When the iron has been parted from the
refiduum by means of an acid, a whitifh
matter, of the weight of 14 grains, remains,
which exhibits almoft all the properties of
felenite ; it is alfo found in the ochre col-
lected by the firft filtering (§ v.). All the
refiduums, and efpecially the laft, are eafily
fufed, with an appearance like boiling, upon
coals excited by the blow-pipe ; they leave
a globular matter, which is attracted by the
magnet, unlefs it has been too long expofed
to the fire. The little folubility of this
fubftance in water, and the appearances it
fhews in the fire, whether by itfelf or in
mixture, fufficiently fhew it to be felenite :
above all, it may be known by decompof-
ing it by fixed alkali in the liquid way ;
for the calcareous earth is precipitated, and
by cryftallization Glauber's falt or vitri-
olated tartar may be obtained, according to
the kind of alkali employed.

The felenite may be ftill better feparated
from the iron, by boiling the dried refiduum
in 500 times its weight of diftilled water,
which diffolves all the faline part, and after-
wards it is eafy to determine the quantity by
weighing, after it has been dried, the ochre
which remains.

§ VIII. *Of*

§ VIII. *Of the ſiliceous Powder.*

If the ſelenite is diſſolved along with the
iron (§ VI. VII.) there remains about half a
grain of very fine powder, which reſiſts the
acids, even when aſſiſted by heat;—when it
has been waſhed and examined, it is found to
be true ſiliceous earth.

§ IX. *Of the Salts.*

By a ſlow evaporation of the water with
which the reſiduum has been waſhed, about
three grains of perfect cryſtals of Glauber's
ſalt may be obtained, which contain only the
ſmall portion of iron that the water of cryſ-
tallization retains: the remaining liquor is
greeniſh, and does not eaſily afford cryſtals;
but when reduced to dryneſs, it affords two
grains of a deliqueſcent matter of an aſ-
tringent, and at the ſame time ſalt taſte:
this matter, tried by different teſts, and eſpe-
cially by precipitants, is found to be vitriol,
but in a highly dephlogiſticated ſtate, and a
little Glauber's ſalt mixed with common
ſalt; this laſt ſhews itſelf both by its taſte,
and one or two cubical cryſtals, but chiefly
by the grey and acrimonious fumes which
ariſe, and by the particular ſmell which it
exhales, when it is moiſtened with a little
concentrated vitriolic acid, and ſome wet
ſubſtance is held over it.

2

§ X. *Prin-*

§ x. *Principles of the Denmark Water.*

From what has been faid before, it may
be concluded that a kanne of the Denmark
water contains

of aerial acid   -   7   cubic inches
of aerated iron   -   o¼   grains, § vi.
of vitriol of iron   14   § vi. and ix.
of Glauber's falt   -   3½   § ix.
of felenite   -   -   14   grains, § vii.
of com. falt, at moft o¾   § ix.
of filiceous, nearly   o¼   § viii.

In all 32¾ grains, which confiderably ex-
ceed the weight of the whole refiduum
(§ v.); but this difference arifes from the
water of cryftallization, which here enters
into the account, and which the heat had
diffipated when the refiduum was weighed
the firft time. If the fame fubftances, in
the fame proportions, are added to diftilled
water that has loft its empyreuma, a folution
perfectly refembling the natural water in
tafte and every other quality will be ob-
tained ; and thus our analyfis is completely
confirmed by fynthefis. It fhould however
be added, that the acidulous water of Den-
mark contains a little extractive vegetable
matter, which without doubt it has received
from the roots that it met with in its paf-
                                                      fage

fage under ground; and probably this is
what impairs its limpidity (§ III.).   One
may fometimes difcover, by mere infpection,
fragments of vegetables.

The variegated pellicle on the furface does
not come from any mineral unctuous fub-
ftance, but from iron in a certain degree
dephlogifticated : fimilar pellicles appear on
folutions of any metallic falts expofed to
the air; they are alfo formed by iron dif-
folved in water by the aerial acid.   Pure air
forcibly attracts the inflammable principle;
and it is evident, from many experiments,
that the colours of metallic calxes vary ac-
cording to the quantity of phlogifton of
which they have been deprived.   The he-
patic fmell plainly points out the way em-
ployed by nature to impregnate this water
with its mineral particles.

Such are the fubftances contained in the
acidulous fprings at Denmark; to treat of
their ufes and efficacy does not fall within
my plan.   It is however, in general, evi-
dent that they muft poffefs virtues different
from thofe of lighter waters in which the
iron is diffolved by the aerial acid : but al-
though the fame effects which the latter
every day produce, cannot be expected from
them, they probably poffefs greater power
and efficacy in thofe cafes which may require
a vitriolic water.

Moreover, the vitriol and felenite are here
the

the active principles; the other fubftances are prefent in fuch fmall quantity that they can have little fhare in producing the effects. With refpect to the felenite, it is found in the Pyrmont water, as well as many other waters of high reputation; but there is great reafon to queftion its falubrity.

DISSER.

DISSERTATION V.

O F

SEA-WATER.

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§ 1. *Water taken up from the Sea at a*
considerable Depth.

THE experienced Doctor Sparrman,
who lately vifited the Southern
Ocean in company with the Forfters, and
who in that voyage, with indefatigable care,
has inveftigated, collected, and defcribed
the wonderful ftores of nature, endeavoured,
during his paffage from the Cape of Good
Hope to Europe, to afcertain the nature and
properties of fea-water taken from a very
great depth :—for this purpofe a number of
glafs bottles with narrow necks, and well
corked, were fucceffively funk, in the be-
ginning of June 1776, about the latitude of
the

the Canaries ; one bottle taken up from the
depth of 80 fathom, was found cracked in
the body by the preffure of the furrounding
fluid ; another, funk to 30 fathom, had the
cork a little thruft in, but not fo that any
water could enter ; it was therefore let down
to 60 fathom, and when brought up was
found filled with water up to the third part
of its neck—in that place the cork, which
had been thruft in, ftuck, fo as not to per-
mit any water to efcape : afterwards many
bottles were filled at that depth, which,
upon his return, Dr. Sparrman fent to me,
requefting me to examine with all poffible
accuracy the heterogeneous matters it con-
tained.

§ 11. *Its Habits with Precipitants.*

This fea-water had no fmell, and the tafte
intenfely falt, not agreeable indeed, but by
no means naufeous, like that which is got at
the furface.

(A) Paper tinged with Brafil-wood was
rendered a little blue, that with turnfole
had its colour fomewhat heightened : thefe
phænomena fhew fome weak tokens of an
alkaline fubftance ; namely, magnefia dif-
folved by means of aerial acid. Tincture of
turnfole was not fenfibly changed.

(B) Acid of fugar immediately preci-
pitated a white powder confifting of faccha-
rated lime.

Q 2   (c) Fixed

(c) Fixed alkali quickly precipitated a white earth, which on examination proved to be magnefia.

(d) Salited terra ponderofa immediately threw down a fpathum ponderofum.

(e) Phlogifticated alkali produced no figns of a blue colour.

Hence we may diftinctly perceive the prefence of lime (B), of magnefia (c), of vitriolic acid (D);—with refpect to common falt there was no doubt.

In order to determine the quantity and quality of the proximate principles, I continued the inveftigation in the following manner.

§ III.   *Principles collected by Evaporation.*

A kanne of this water (the fpecific gravity, compared with diftilled water, was 1,0289) upon evaporation to drynefs, yielded a refiduum which, when well exficcated, weighed 3 ounces 378 grains.

(A) This refiduum, well wafhed with alcohol, and dried, was diminifhed in weight 380 grains.

The folution, diluted with diftilled water, depofited, on the addition of mineral alkali, a magnefia; and the liquor, on evaporation, yielded common falt.

(B) In order to difcover whether there was any vitriolated magnefia prefent, I added to the faline mafs, wafhed with alcohol,

a fmall

a small quantity of warm water, and suddenly decanted it off. This water, on examination, shewed no signs of vitriolated magnesia, either in taste or by precipitation, and contained nothing but a small portion of common salt.

Vitriolated magnesia is very easily dissolved in boiling water, whereas of pure common salt scarcely any more is taken up by hot than by cold water; by the above method, therefore, they may easily be separated. Some moderns contend, that more of common salt is taken up by cold, than by warm water; but this assertion is contrary to the nature of things, and to experience : upon accurate examination I found the quantities taken up by boiling water, and by water of a moderate heat, to be respectively as 77 to $71\frac{1}{2}$.

(c) The common salt was dissolved in a quantity of cold water so small, that it could take up no more; and therefore a white powder remained, which appeared to be gypsum.

(d) This gypsum excited in distilled vinegar a very slight effervescence, which soon went off, but the gypsum was scarce sensibly diminished.

(e) Upon collecting and weighing all the contents, each kanne is found to contain

of

	Ounces.	Grains.
of common falt – –	2 –	433
of falited magnefia –	0 –	380
of gypfum – – –	0 –	45
	3 –	378

The magnefia which adhered to the gyp-
fum, and had been diffolved by the aerial
acid, is found in fuch fmall quantity as not
to amount to $\frac{1}{8}$ of a grain.

§ iv. *The Ufes of Sea-water.*

If fea-water taken from a confiderable
depth be always of the fame nature with
that above examined, we may conclude that
fuch water is free from the ordinary nau-
feous flavour; and this fuppofition alfo agrees
with other phænomena; for the innu-
merable croud of fifh, infects, and vege-
tables, that grow, live, and perifh in the
water, as foon as they begin to grow pu-
trid, fwell, and rife to the furface, or at
leaft fuch parts of them as are extracted by
the water: on the furface thefe meet with
a fufficient quantity of falt, and free accefs of
air, circumftances which wonderfully pro-
mote putrefaction. This deftruction is a
neceffary part of the œconomy of nature;
and thus many circumftances, with joint
force, contribute to this operation; the ne-
ceffary confequence of which I apprehend
is,

is, that naufeous and loathfome tafte occa-
fioned by the putrid particles near the fur-
face ;—but, whatever be the caufe, provided
the fact be uniform and conftant, an advan-
tage of no trivial nature may be derived from
it for the benefit of feamen ; for fea-water,
taken up at this depth at leaft, diluted with
an equal quantity of frefh water, may be
employed for the boiling of provifions, by
which means one half of the frefh water will
be preferved ; and perhaps in time of ur-
gent neceffity a greater faving might be
made.

DISSERTATION VI.

OF THE

ARTIFICIAL PREPARATION

OF

COLD MEDICATED WATERS.

———————

§ 1. *Reasons for the present Undertaking.*

THERE are four remarkable species of
mineral waters; namely, the Seyd-
schutz, Seltzer, Spa, and Pyrmont waters,
which are imported into Sweden; physicians
having found these so useful against infirmi-
ties and diseases, that a considerable quantity
of them is prescribed and used every year.

But as these waters either cannot be had
amongst us at all during the winter and
spring, or at least not fresh, although the
most powerful remedy for the diseases which
prevail at that time of the year: as the
poor cannot purchase them at the price
which they commonly bear;—as they lose

<div align="right">more</div>

more or lefs of their virtue during the voyage ;—and finally, as they draw yearly confiderable fums of money out of the king-dom ;—I thought it worth while to examine, with all poffible accuracy, the conftituent principles of thefe waters : hoping that, thefe principles being once known, the waters themfelves might be prepared in any part of the world. Whether or not I have fucceeded let the candid and fkilful judge from the following pages.—We now pro-ceed to the analyfis of thefe waters, as they muft be thoroughly known, before they can be imitated.

§ 11. *Analyfis of Seydfchutz Water.*

Principles collected by Evaporation.

The tafte of Seydfchutz water is extreme-ly bitter and difagreeable : in boiling it feparates a white powder, which, collected on a filter, wafhed and dried, exhibits a genuine aerated lime ; for, when faturated with vitriolic acid, it is all converted into gypfum.

(B) After the greateft part of the water is evaporated a gypfeous pellicle appears on the furface, which muft be carefully taken away, as long as the leaft veftige of that falt fhall appear during the evaporation. The gypfum, collected and wafhed, effervefces a little with diftilled vinegar ; this effer-

vefcence

vefcence depends upon the admixture of magnefia alba, which may alfo be precipitated from the acid menftruum by alkali of tartar : however, a fmall quantity of gypfum will remain in the water, even after it has ceafed to produce diftinct pellicles.

(c) The refiduum is of a brown colour ; and on repeated evaporation this water yields, almoft to the laft drop, cryftals of a bitter falt, which is totally decompofed by lime-water, and is therefore genuine (a) vitriolated magnefia ; for Glauber's falt contains the mineral alkali, which does not yield the vitriolic acid to lime. The cryftals, collected and diffolved in a fmall quantity of water, depofit on the bottom of the yeffel that fmall portion of gypfum above-mentioned (B). Thefe cryftals alfo contain a falited magnefia, which partly unites with the water of the cryftals, partly adheres to them externally, and may be feparated by fpirit of wine.

Salited lime cannot exift in water which contains vitriolated magnefia, for the proximate principles of thefe falts are immediately changed by a double elective attraction; the vitriolic acid feizing the lime, and leaving the magnefia to the marine acid.

Upon repeating the analyfis of Seydfchutz water, I found that the different

(a) On Magnefia, § v.

fubftances

fubftances may be feparated as well, or bet-
ter, by continuing the evaporation at firft to
drynefs, and afterwards feparating the one
from the other.

(D) In order to determine the quantity of
fixed air contained in the water, I at firft
made ufe of a copper cylindrical veffel, fit-
ted with a conical top (A B C D, tab. ii.
fig. 1.) into this I put another leffer cylin-
der (E F G H) open at the bottom, and ftand-
ing upon three feet, but clofed at the top,
except the little tube 1, whofe upper ori-
fice fhould ftand about half an inch beneath
the furface of the water, filling the veffel ;
and the procefs is thus conducted :— the
external and internal veffels are filled with
the water under examination ; then a glafs
bottle, filled with warm water, is inverted,
by means of the fpoon L, in fuch a manner
over the tube 1, that no air bubbles fhall
enter : the water is then boiled as long as
the vapour, and that only, arifes in the form
of bubbles ; mean time the water contained
in the internal veffel is forced by the heat to
emit its air, which rifes through the tube 1,
and is collected in the bottle ; if neceffary
the firft bottle may be removed, and fet in a
veffel of warm water, while another is in-
verted over the tube as quickly as poffible,
in order to prevent the efcape of any of the
air : finally, the fpace occupied by the air
in one or more bottles is to be meafured,
and

and that in an heat of 50°, to prevent the ab-
forption of air.

This fpace, compared with the capacity
of the internal veffel, fhews nearly the quan-
tity of air contained in a given meafure of
the water. Such a method I practifed at
firft ; but, although the water in the bottle
be heated to the 50th degree, I have found
that it abforbs fome of the air ; I therefore
afterwards made ufe of mercury, which, if
the operation be properly conducted, fhews
exactly the quantity of air required (fee
Analyfis of Waters, VIII. A, B). The bulk
varies acccording to the gravity and tempe-
rature of the atmofphere ;—hence we fhould,
as much as poffible, chufe determined de-
grees of heat and weight.

It is alfo to be obferved, that the aerial
matter thus collected generally confifts of
two different elaftic fluids, the one per-
fectly agreeing with the aerial acid, the
other with pure air ; that is, air fit for fup-
porting flame and animal refpiration. Com-
mon water abforbs the firft of thefe, but
not the latter, being already faturated with
it ; and by this method the two fluids may
be feparated to a certain degree.

(E) The feveral matters obtained by the
analyfis above defcribed are in quantity as
follows : a Swedifh kanne (that is, 100
cubic inches) of Seydfchutz water con-
tains

				grains.
of aerated lime	-	-	-	$4\frac{1}{2}$
of vitriolated lime		-	-	$24\frac{1}{2}$
of aerated magnefia		-	-	$12\frac{1}{2}$
of vitriolated magnefia		-	-	$859\frac{1}{2}$
of falited magnefia		-	-	$21\frac{3}{4}$
				$922\frac{3}{4}$

The aerial fluid expelled by heat amounts to little more than fix cubic inches, nearly four of which are aerial acid; and the remainder pure air.

(F) As 100 cubic inches of aerial acid can diffolve no more than 27 grains of aerated lime in a kanne of water (fee Treatife on Aerial Acid), 4 cubic inches can fcarcely take up more than one; the greateft part, therefore, of the aerated lime found in Seydfchutz water is mechanically fufpended in it, by means of the minutenefs of its parts.

Salited magnefia may be partly decompofed, by bare evaporation to drynefs—hence we muft not conclude, that all the magnefia which, upon analyfis, is found in a difengaged ftate, has always exifted in the water in that fame ftate, but rather that it has been united with marine acid in greater or lefs quantity, according to the degree of heat applied in the evaporation. Salited magnefia is eafily difcovered, as it diffolves flowly, and without effervefcence, in acids.

§ III.

§ III. *The Appearances of Seydfchutz Water with Precipitants.*

(A) Tincture of turnsole, made with distilled water, and so diluted as to appear distinctly (*b*) blue, does not grow red upon the addition of Seydfchutz water—this is owing to the small quantity of aerial acid ; but paper tinged by turnsole is made more distinctly blue, which is occasioned by the aerated lime and (*c*) magnesia. If any disengaged alkaline salt be present, it is easily discovered, by means of paper tinged by turmeric, which is quickly and distinctly made brown by alkalis, but is not affected by aerated earths.

Paper tinged by fernambucum grows quickly blue, upon the addition of Seydfchutz water.

(B) Spirituous tincture of galls (as well as phlogisticated alkali) neither changes the colour of Seydfchutz water, nor precipitates any thing metallic.

(C) Caustic vegetable alkali immediately renders Seydfchutz water turbid, and precipitates white spongy flocculi. The precipitate in this case is magnesia detached from vitriolic and nitrous acid.

(*b*) On Aerial Acid, § VI.
(*c*) Ibid, § XI and XII.

7

(D) A

(D) A few drops of concentrated vitriolic acid occasion no visible change; the particles of aerated lime and magnesia are too much diffused to make the effervescence observable; it may however be made manifest by bringing them closer together by evaporation, although in this case the calcareous particles have before totally separated; a circumstance which takes place even in a moderate degree of heat.

(E) The acid of sugar, either alone or united with vegetable alkali, instantly discovers the most minute particle of (d) lime, whatever acid it be united with; for this acid attracts lime with such force, that it expels even the vitriolic itself, and all the other acids hitherto known, and forms with it a salt very difficult of solution, which therefore immediately falls to the bottom in form of a white powder. This acid, when added to Seydschutz water, instantly precipitates a saccharated lime.

(F) That substance which is commonly called oil of lime separates, though slowly, a gypsum from Seydschutz water; and this is effected by a double decomposition, the vitriolated magnesia and the salited lime changing primary principles.

(G) A small piece of pure alum, put into Seydschutz water, in the space of a quarter of an hour occasions an earthy stratum near the

(d) Of the Acid of Sugar, § VI.

bottom of the veffel, which, on examination, is found to be argillaceous : this is produced by the vitriolic acid forfaking its bafe, and feizing the aerated magnefia.

(h) Solution of filver makes Seydfchutz water immediately turbid ; for vitriolic and marine acid, when prefent, feparate the filver from nitrous acid.

(i) Solution of mercury in this cafe precipitates a turbith mineral, and that white, in inverfe proportion to the dephlogiftication of the metal during its folution. If the mixture be fuffered to ftand quiet, a whitifh cloud is formed over the turbith mineral, which is no other than a falited mercury.

(k) Corrofive fublimate precipitates flowly a white fediment, which confifts of an aerated (e) mercurial calx, and is readily precipitated by means of lime or magnefia aerated.

(l) Saccharum faturni, or, to fpeak more properly, acetated lead, precipitates a white powder, which is a vitriol of lead, occafioned by the decompofition of vitriolated magnefia. The whitenefs of this powder demonftrates the abfence of fulphureous matter.

(m) Martial vitriol is converted into an ochre, during its folution in Seydfchutz water, becaufe the aerated lime and magnefia feparate the vitriolic acid, and the pure

(e) On Aerial Acid, § xii.

5

air

air contained in the water dephlogifticates
the metallic bafe : vitriol in like manner
depofits an ochre in a bottle full, and well
ftopped. All thefe phænomena, therefore,
demonftrate the prefence of the feveral mat-
ters which were before afferted to be con-
tained in Seydfchutz water.

§ IV. *Specific Gravity.*

I compared the fpecific gravity of Seyd-
fchutz water with that of the beft common
water (diftilled by a flow fire) and that in
an heat of 15°; repeated experiments deter-
mined its fpecific gravity to be to that of
diftilled water, as 1,0060.

Although the fpecific gravity of a folu-
tion, is rarely agreeable to that of the ingre-
dients taken together, the following compa-
rifon will not be without its ufe :

A kanne of the pureft fnow-water, dif-
tilled flowly, is nearly equal in weight to
42,250 grains ; the fame meafure of Seyd-
fchutz water weighs 42,503 ; the differ-
ence therefore is 253 grains. But in § 11. we
got, from a kanne of Seydfchutz water, no
lefs than 922½ grains, which is nearly four
times the laft number.—We muft now take
into confideration the water of the cryftals,
which in 100 of aerated lime makes 11 ;
of vitriolated lime 22 ; of aerated mag-
nefia 30 ; of vitriolated magnefia 48 ; and
of falited magnefia, nearly 40.—Hence, a

R   calculation

calculation being made, we find the water of cryſtallization of the ſubſtances contained in a kanne of Seydſchutz water to be 431 grains. Hence $923 - 431 = 492$; but $492 - 253 = 239$, which ſtill ſhews a conſiderable difference: but this difference will ſoon vaniſh, ſuppoſing the ſpecific gravity of the ſalts to be in general 2; and that, conformable to the moſt accurate experiments, no mutual penetration takes place; — for 492 grains of ſalts, put into a kanne of diſtilled water, diſplace only ſo much water as is equal to $\frac{492}{2} = 246$; the weight therefore of a kanne of diſtilled water in which 492 grains of ſalts are diſſolved $= 42,250 + 246 = 42,496$; but $42,503 - 42,496 = 7$. Now, ſince 6 cubic inches of atmoſpheric acid weigh about three grains, we have at length $7 - 3 = 4$ grains, indicating nearly how much has been loſt, during the operation, on the filters and veſſels.

§ v. *Analyſis of Seltzer Water.*

Principles collected by Evaporation.

Seltzer water, beſides a ſubtile pungent acidity, excites upon the tongue a taſte gently ſalt, and mildly alkaline.

(A) By quick boiling it depoſits an aerated lime, which had been diſſolved by means of ſuperabundant aerial acid; — this, collected on a filter, is found to contain

scarce

fcarce any aerated magnefia, as this laft is both more eafily diffolved, and retains the quantity of volatile menftruum neceffary for folution more obftinately than the lime does.

(B) By a continued evaporation the magnefia feparates, but, as it continues to feparate during the whole evaporation, it cannot be collected by filtration; we muft therefore evaporate to drynefs, wafh the refiduum with hot diftilled water, and at length the magnefia will remain alone at the bottom.

(c) The folution which is obtained by warm water yields, on cryftallization, two falts; the one an alkali, which, with vitriolic acid, forms a true and pure Glauber's falt, and is therefore no other than genuine mineral alkali; the other cubic, agreeing perfectly with pure culinary falt.

Salited magnefia, which almoft always accompanies culinary falt, is in this cafe not to be found; nor could it poffibly be fo, on account of the difengaged alkali.

(D) The weights of the feveral matters contained in a kanne of Seltzer water are as fet forth in the following table.

		grains.
Aerated lime	– –	17
Aerated magnefia	–	$29\frac{1}{2}$
Cryftallized mineral alkali		24
Common falt	– –	$109\frac{1}{2}$
		180

The

The aerial fluid fometimes amounts to 60 cubic inches, which is almoft all aerial acid; for the pure air fcarcely exceeds a fingle cubic inch.

§ VI. *The Habitudes of Seltzer Water with Precipitants.*

(A) Tincture of turnfole grows red upon the addition of a fmall portion of Seltzer water; but in the open air the blue colour gradually returns—a change which takes place immediately upon the application of heat.

Paper tinged with tincture of turnfole is rendered more diftinctly blue by this water; that tinged by Brazil wood grows blue; and that tinged yellow by turmeric is but little changed: however, if the ingredients be reduced to a fmall fpace by evaporation, this paper affumes a brownifh red.

(B) Tincture of galls and phlogifticated alkali produce no figns of any thing metallic.

(c) Cryftallized vegetable alkali produces no effect; but the cauftic alkali precipitates a white powder, which effervefces with vitriolic acid, and forms a gypfum: this, therefore, is aerated lime, deprived of the portion of volatile menftruum neceffary for its folution.

(D) The ftrong acids occafion a great number of bubbles, which confift of the

aerial

aerial acid expelled from the alkali and the aerated earths.

(E) Acid of fugar immediately feizes the lime, and falls to the bottom.

(F) Salited terra ponderofa precipitates no fpathum ponderofum, which moft evidently fhews the abfence of vitriolic acid; for that acid attracts terra ponderofa with fuch force, that, deferting every other bafe, it unites with that earth in the form of nearly infoluble atoms.

(G) Salited lime does not precipitate a calcareous powder until after a day or two. — This precipitate is occafioned by the mineral alkali which the aerial acid, fo long as it remains in fufficient quantity, holds fufpended.

(H) Alum is decompofed in like manner by the difengaged alkali.

(I) Solution of filver renders Seltzer water immediately milky, being partly converted into a falited filver, partly yielding its acid to the alkaline falt.

(K) Solution of mercury, made without heat, in nitrous acid, occafions a copious white precipitate;—the folution made by heat caufes a yellow one.

(L) Corrofive fublimate precipitates a white powder, but not until after fome days. —If about $\frac{1}{7}$ of the water be diffipated by evaporation before the fublimate is added, no change is obferved, but after a few days blackifh cryftals appear by degrees; of thefe

cryftals

cryſtals we have already treated (on Aerial Acid, § XII).

(M) Cryſtallized ſaccharum ſaturni im‑ mediately precipitates a white ſediment, which is all ſoluble in vinegar.——The ſame happens with lead, either united with ma‑ rine acid or precipitated by fixed alkali. Vitriol of lead is not ſoluble in vinegar.

(N) Vitriol of iron depoſits a white ſedi‑ ment, which gradually grows yellow, even in a bottle full and well ſtopped.

§ VII. *Specific Gravity of Seltzer Water.*

In a moderate heat I found the ſpecific gravity of Seltzer water to be 1, 0027, hence the weight of one kanne ſhould be 42,363 grains, which, calculating from the ingre‑ dients, will be $42,250 + \frac{180-31}{2} = 42,324\frac{1}{2}$, as the water forms about 31 grains, 64 to every hundred of alkali, allowing 6 to the ſea ſalt, and the reſt as in § IV. The weight of 60 cubic inches of aerial acid is nearly 30 grains, therefore $42,363 - 42,324\frac{1}{2} - 30 = 8\frac{1}{2}$; the difference of weights of a kanne, one of which is computed by the ſpecific gravity, the other from the quantity of the heterogeneous contents.

§ VIII. *Analyfis of Spa Water.*

Principles collected by Evaporation.

Spa water has a martial fub-alkalefcent, mild, and gently pungent tafte. On expofure to the open air for fome hours it contracts a fhining variegated pellicle on the furface.

(A) By quick boiling it feparates a ferruginous powder; let this, collected by filtration, and a little roafted, be put into vinegar, for this menftruum diffolves the earthy parts, leaving the dephlogifticated iron untouched.—Whatever is afterwards precipitated from the vinegar by an alkali is no other than an aerated lime.

(B) During the whole progrefs of evaporation, even to the very end, a white powder is continually feparating, which may be obtained from the dry refiduum by fufficient wafhing carefully conducted. This generally diffolves in vinegar, with effervefcence, and is found to poffefs the properties of aerated magnefia; but fometimes a part remains untouched, this is gypfum, and rarely amounts to a grain in a kanne.

(C) The water with which the refiduum has been wafhed, on cryftallizing exhibits the mineral alkali, mixed with a few cubes of common falt. This alkali, united with vitriolic acid, forms a genuine Glauber's

R 4   falt,

falt, fometimes intermixed with a few cryftals refembling vitriolated vegetable alkali.

(D) The experiments hitherto made, fhew that a kanne of Spa water contains

		grains.
of aerated iron	—	$3\frac{3}{4}$
of aerated lime	-	$8\frac{1}{2}$
of aerated magnefia	-	20
of cryftallized mineral alkali		$8\frac{1}{2}$
of common falt	-	1
		$41\frac{3}{4}$

The aerial fluid collected rarely amounts to 45 cubic inches; which is all aerial acid, and is abforbed by water. — I found not any pure air, and perhaps it could not long exift together with aerated iron, as the pure air feizes the phlogifton, and flies off with it.

§ IX. *Habitudes of Spa Water with Pre-cipitants.*

(A) One part of Spa water generally reddens 25 of tincture of turnfole. The paper tinged by turnfole is rendered of a more vivid blue; that tinged by fernambucum is made blue; but paper coloured by turmeric is fcarcely changed, until the water has been a good deal reduced by evaporation.

(B) A fingle drop of tincture of galls renders Spa water purple; and phlogifticated alkali

alkali produces, though flowly, Pruffian blue.—Spa water, after boiling, does not exhibit the fmalleft fign of iron, either by thefe precipitants, or by any other method.

(c) Cauftic fixed alkali, after 24 hours, feparates, though fparingly, a white calcareous powder. The cryftallized alkali has no other effect than to deprive the water of its pungent flavour.

(d) Concentrated acids occafion a great quantity of bubbles.

(e) Saccharated vegetable alkali, as alfo acid of fugar alone, precipitates lime but fparingly.

(f) Salited terra ponderofa very rarely feparates any thing, and when it does, it is very flowly; which indicates either the abfence of vitriolic acid, or that its quantity is extremely fmall.

(g) Salited lime, after 24 hours, is precipitated by the fixed alkali of the water.

(h) Alum depofits its earth.

(i) Solution of filver throws down a fine white powder.

(k) Solution of mercury, made without heat, yields a yellowifh white precipitate; that made with heat a brownifh yellow.

(l) Corrofive fublimate, after 24 hours, feparates a grey powder, which, if the water be previoufly concentrated by evaporation, is of a brownifh yellow.

(m) Accetated

(M) Acetated lead forms a white precipitate.

(N) Martial vitriol yields a white powder, which gradually grows yellow.

§ X. *Specific Gravity of Spa Water.*

In an heat of $15°$ the specific gravity of Spa water is 1,0010, hence the weight of one kanne should be 42,292 grains;—but the water of the residuum is about $14\frac{1}{2}$, and the weight of 45 cubic inches of atmospheric acid $= 22\frac{1}{2}$;—therefore $42,292 - 42,250 + \frac{41-12}{2} + 22\frac{1}{2} = 5$; which is the difference sought.

§ XI. *Analysis of Pyrmont Water.*

Principles collected by Evaporation.

Pyrmont water possesses a most agreeable, subacescent, pungent flavour, not unlike that of Champaigne wine, but at the same time martial, and a little bitterish; in the open air, it contracts a pellicle like the Spa water.

(A) During ebullition aerated iron, together with aerated lime, is separated; the former may be easily separated from the latter, by means of vinegar, as above described (VIII. A).

(B) After filtration, let the evaporation be continued to dryness; let the residuum,

washed

wafhed with a fufficient quantity of diftilled water, be put into vinegar: the part thus diffolved fhews the properties of magnefia; that which remains untouched is found to be gypfum.

(c) The water with which the refiduum has been wafhed, being evaporated, exhibits at firft true vitriolated magnefia; but towards the end, magnefia mixed with common falt, which may in fome degree be feparated by conducting the evaporation very flowly.

(d) All the ingredients being carefully weighed, there are found in each kanne of Pyrmont water,

		grains.
of aerated iron	-	$3\frac{1}{4}$
of aerated lime	-	20
of vitriolated lime	-	$38\frac{1}{2}$
of aerated magnefia	-	45
of vitriolated magnefia		25
of common falt	-	7
		$138\frac{3}{4}$

The aerial fluid collected fometimes amounts to more than 90 cubic inches, and confifts entirely of aerial acid; in general, however, the quantity of aerial acid is much fmaller.

§ XII.

§ XII. *Appearances of Pyrmont Water with Precipitants.*

(A) Pyrmont water communicates a deeper red tinge to tincture of turnsole than Spa water does. The paper stained by turnsole has its colour heightened; that with fernambucum grows blue; that with turmeric is not changed, even though the water has been much evaporated.

(B) Tincture of galls and phlogisticated alkali soon discover iron; but the water, after boiling, shews no signs of that metal.

(C) A single drop of caustic fixed alkali, throws down a white earth, which, on examination, exhibits the qualities of magnesia.

(D) Concentrated acids occasion an effervescence.

(E) Acid of sugar precipitates lime quickly and copiously.

(F) Salited terra ponderosa indicates vitriolic acid, for a spathum ponderosum precipitates.

(G) Salited lime occasions a gypseous precipitate, which after 24 hours becomes visible.

(H) Alum is decomposed, even after the lime is separated; this effect is therefore produced by the aerated magnesia.

(I) Solution of silver occasions a milky turbidness.

(K) So-

(K) Solution of mercury, made without heat, occasions a whitish yellow precipitate; that made with heat, exhibits a more copious sediment, of a deeper yellow; in both cases, if the solution be gently dropped in, and the water suffered to stand quiet, a white cloud is suspended over the bottom of the vessel, which indicates a salited mercury.

(L) Corrosive sublimate after 24 hours produces an ochry precipitate, soluble in vitriolic acid; Pyrmont water, much evaporated, deposits a white powder, upon the addition of corrosive sublimate.

(M) Acetated lead yields a white powder, great part of which resists the action of vinegar.

(N) Martial vitriol yields at once a white precipitate, which grows yellow, though slowly.

§ XIII. *Specific Gravity of Pyrmont Water.*

The specific gravity of Pyrmont water is found, in a moderate heat, to be 1,0024; the weight, therefore, of one kanne is 42,351 grains; but as the water of the residuum is $36\frac{1}{4}$, and the weight of 90 cubic inches of atmospheric acid is 45, $42,250 + \frac{13\frac{5}{2} - 36\frac{1}{4}}{2} + 45 = 5$; the difference by which the weight of a kanne, computed by its specific gravity, exceeds the weight deduced from the quantity of heterogeneous contents.

§ XIV. *Com-*

§ XIV. *Comparifon of the Waters above examined.*

That we may have, in one fynoptical view, the contents of all thefe waters, we fhall fet the whole in order in the following Table.

TABLE.

TABLE of CONTENTS of the cold medicated Waters, in Grains.

	Seydfchutz.	Seltzer.	Spa.	Pyrmont.
Aerated lime	$4\frac{1}{2}$	17	$8\frac{1}{2}$	20
Vitriolated lime	$24\frac{1}{2}$	—	—	$38\frac{1}{2}$
Aerated magnefia	$12\frac{1}{2}$	$29\frac{1}{2}$	20	45
Vitriolated magnefia	$859\frac{1}{2}$	—	—	25
Salited magnefia	$21\frac{3}{4}$			
Aerated mineral alkali	—	24	$8\frac{1}{2}$	
Salited mineral alkali	—	$109\frac{1}{2}$	1	7
Aerated iron	—	—	$3\frac{1}{4}$	$3\frac{1}{4}$
Sum total	$922\frac{3}{4}$	180	$41\frac{1}{2}$	$138\frac{3}{4}$
Greateft quantity of aerial acid, in cubic inches	4	60	45	90
Pure air	2	1		
Specific gravity	1,0060	1,0027	1,0010	1,0024

§ xv. *Con-*

§ xv. *Conjecture concerning the Way in which Nature prepares these Waters.*

Among the waters now examined, the Seydschutz contains scarcely more aerial acid than common fountain water: to account, therefore, for the origin of this water, such a situation of its channels as may conduct it through strata of aerated lime, &c. is sufficient; and these strata are found in many places; the water passing through these by degrees takes up the quantity which is found in it as above.

The three others possess so large a quantity of aerial acid, that they could not have received it from the atmosphere. This elastic vapour is abundantly extricated in three different ways (on Aerial Acid, § 11.) namely, by fermentation, by fire, and by the action of a more powerful acid : the first of these can scarcely be supposed to take place in the bowels of the earth; but I see no reason why the other two may not operate, either jointly or separately : — Thus subterranean fire expels the aerial acid from calcareous earth, and still more readily from magnesia; and it is the more readily absorbed by the water which it meets with, in proportion as that water is the more divided into channels, as it is the more cold, and the more compressed by the subtile elastic fluid. Nor is the third method attended

attended with any difficulty; for al-
though, on the furface of the earth, water
fcarcely ever contains an uncombined mi-
neral acid, yet in the bofom of the earth
the vitriolic acid muft be often fet free by
the deflagration of fulphur ; and perhaps the
marine acid may be extricated from falited
lime and magnefia by fubterraneous fire.
—We fhall foon fee the effects of earthy and
metallic falts, when decompofed by mineral
alkali or alkaline earths.

Let us firft confider the Seltzer water;
and begin by enquiring whether it owes
its aerial acid (which is the chief point
in queftion, the other ingredients being
found in the bofom of the earth) to the de-
compofition of middle falts by an alkali; or
to alkalis directly diffolved in acids ; or, fi-
nally, to the extrication of that elaftic fluid
by fubterraneous heat alone.

To examine the firft fuppofition, let us
fuppofe that water loaded with falited lime
and magnefia meets with an aerated alkali ;
now a kanne of Seltzer water contains
$109\frac{1}{2}$ grains of common falt, in which there
are about 46 of pure mineral alkali ; and
thefe require about 37 of aerial acid to
faturate them ; that is, 74 cubic inches,
becaufe each cubic inch weighs about half
a grain : but $45\frac{1}{2}$ grains of pure lime may
be precipitated by that quantity of alkaline
falt ; and thefe immediately abforb about
28 grains of aerial acid. In the fame

S   manner,

manner, by an equal quantity, upwards of 35 grains of pure magnefia are precipitated; and this quantity, in precipitating, carries along with it at leaft $19\frac{1}{2}$ grains of ae- rial acid. Making a calculation, there- fore, it appears, that in the firft cafe there only remain to faturate the water 37 — 28 = 9 grains = 18 cubic inches of aerial acid, which is not fufficient for the pur- pofe (§ xiv); and in the cafe of the mag- nefia 37 — $19\frac{1}{2}$ = $17\frac{1}{2}$ grains = 35 cubic inches; a quantity far too fmall (§ xiv). The common falt, therefore, which is prefent in Seltzer water, does not feem to originate in this way, fuppofing that the water at once receives the 60 cubic inches of aerial acid; but if the water contains fo much marine acid as is fufficient for the imme- diate production of 109 grains of common falt, the end will be completely obtained, as all the 74 cubic inches can without di- minution be applied to that purpofe. There is no doubt but this may take place, if the aerial acid be expelled by fire.—We now pro- ceed to confider the two martial waters.

Pyrmont water contains 7 grains of common falt in a kanne; which, if we fup- pofe them generated from falited magnefia, precipitated by mineral alkali, will give fcarce more than 3 cubic inches for aerating the water. The vitriolated lime and mag- nefia are of no ufe in this procefs, unlefs generated in the water itfelf, either by means

means of a difengaged vitriolic acid, or, as is more probable, by the decompofition of martial vitriol.

A kanne of Pyrmont water contains 38½ grains of gypfum, and 25 of vitriolated mag-nefia : thefe two falts together contain about as much vitriolic acid as 67 grains of cryftallized green vitriol. Let us then fup-pofe, that water impregnated with this quantity of vitriol meets with 20½ grains of aerated lime, and about 11 grains of aerated magnefia, and the above-mentioned falts will appear ; and during this operation the former bafe gives out 16½ cubic inches of aerial acid, and the latter 6 ; but 22½ cubic inches fcarce amount to a fourth part of the neceffary bulk, even adding 7, which are got from the common falt, fup-pofing it to be generated in the water ;—a great deficiency, therefore, ftill remains, fo that we muft try another method.

Let us fuppofe a kanne of water loaded with 276 grains of vitriol (which is by no means extravagant, as that quantity of water can take up upwards of 6,000 grains) meets with 235 grains of aerated lime ; in this cafe not only 100 cubic inches of aerial acid will be extricated, but enough of the iron and gypfum will be diffolved to faturate the water. Thus, then, by the addition of 25 grains of vitriolated magnefia, we have a complete Pyrmont water.

It

It is otherwife with the Spa water—this is very poor with refpect to the quantity of faline contents; and, with regard to the nature of thefe falts, is fuch, as to require a quantity of aerial acid, that has been extricated externally;—in this water, befides the mineral alkali, lime, magnefia, and iron (all of which are united with aerial acid) there is nothing contained, except a fingle grain of common falt—hence it is plain, that this water cannot be aerated, either by the faturation of marine acid, or by the decompofition of middle falts in the water itfelf. Now, in the neighbourhood of Spa there are no veftiges of fubterraneous fire; how then does the water acquire the aerial acid in the bofom of the earth? We firft obferve, that veftiges of fubterranean fire, once abundantly manifeft, are by lapfe of time often fo defaced, as to be fcarcely difcernible; befides, a degree of fubterraneous fire, fufficient to extricate this fubtile acid, may eafily exift, without producing earthquakes or eruptions of any kind, and that for any length of time, provided the caufes be fo tempered that the effects may remain the fame; neither is it neceffary that the efficient caufe fhould be in the neighbourhood, for the fuperficial ftrata of this globe are perforated in almoft every direction, fo that the elaftic fluid may come through a variety of channels, from places very remote. In the prefent inftance it appears, that the

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aerial

aerial acid muſt have paſſed through a
length of way, as it is found to have de-
poſited all its heat ; but martial vitriol
alone, diſſolved in water, and penetrating
ſtrata, which contain either alkaline ſalts,
lime, or magneſia, may, by decompoſition,
extricate a ſufficient quantity of aerial acid ;
which being conducted to a great diſtance
from the place of its origin, may be ſo
united with water, that ſuch water ſhall not
exhibit the ſlighteſt marks of thoſe ſub-
ſtances which contributed to its impregna-
tion.

I have ſometimes found a ſmall portion
of gypſum in Spa water, in the quantity of
about one grain to a kanne ; but how can
this be, if we ſuppoſe a diſengaged mineral
alkali (or rather an alkali only, united with
aerial acid) to be preſent, as ſuch an alkali
attracts the vitriolic acid more powerfully
than lime does ? We may obſerve firſt, that
there is only $\frac{1}{100}$ of a grain of gypſum in
a cubic inch of water ; and of the mineral
alkali, no more than $\frac{1}{10}$ of a grain ; for the
combination of mineral alkali and aerial
acid is not ſpontaneouſly decompoſed : ſub-
ſtances, therefore, which are ſo thinly ſcat-
tered through the water, may reaſonably be
ſuppoſed to act very ſlowly upon each other,
eſpecially as the alkali, when aerated, is very
inactive. An example will ſhew how the
activity of ſubſtances is repreſſed by ae-
rial acid : — let vitriolated magneſia be

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diffolved in water; drop in a little lime-water, and inftantly the magnefia falls to the bottom, having yielded its acid to the lime; but if pieces of chalk or calcareous fpar be put into the folution, no decompo-fition can be produced, even by boiling: hence we fee how, in Seydfchutz water, vitriolated magnefia may exift, together with aerated lime.

Befides, moft commonly there is no gyp-fum found in Spa water: whether this hap-pens becaufe the water is taken from dif-ferent fprings, or whether the number of principles is not always the fame in the fame fpring, I have no doubt but that the proportion of the ingredients does fre-quently vary, and I am confirmed in this opinion by experience, and the nature of the thing itfelf.

§ XVI. *Whether the Waters above examined be imitable by Art.*

The completion of any analyfis can by no other means be fo clearly evinced as by pro-ducing fynthetically a perfect imitation of the thing analyfed; as it thence appears that we have not only difcovered the primary principles, but alfo the true method of uniting them. We are now to try what can be done in the prefent cafe. From what has been faid it appears that the art of pre-paring medicated waters comprehends two

circumftances

circumftances of moment; firft, it is re-
quifite that water, pure, and totally deftitute
of every fort of tafte, be as it were vi-
vified by aerial acid, which conftitutes the
genuine mineral fpirit as it is called; by
this the water acquires a grateful, fubtile,
penetrating tafte, together with fingular vir-
tues; but the efficacy of this acid muft be
feconded by other groffer fubftances, which
determine the peculiar nature of the water;
fo that one fhall refemble Seltzer, another
Spa, and a third Pyrmont water;— the firft
of thefe differs much from the other two in
its nature and properties, nor do the two
chalybeate waters altogether agree. It is
not therefore fufficient, for the imitation of
thefe mineral waters, to be acquainted with
the method of impregnating water with
aerial acid: the principles proper to each,
from whence their fpecific virtue and effi-
cacy is derived, muft alfo be accurately un-
derftood.

Many perfons are firmly perfuaded, that
in the natural production of medicated wa-
ters there takes place a certain degree of fer-
mentation, as they are pleafed to call it,
which can never be imitated by art: but
thofe who are well acquainted with the fub-
ject are of a very different opinion. The
queftion is entirely reducible to this, viz.
to difcover accurately the heterogeneous con-
tents of thofe waters, and to unite thofe he-
terogeneous matters with pure water. It

S 4   can

can be of little confequence whether the water difperfed through the bowels of the earth, by paffing through certain ftrata extract certain materials, or whether thofe very materials be artificially added in proper quantity :—the hand that fupplies the ingredients can make no difference in the refult.

§ XVII. *The Method of aerating Water.*

The moft fimple method is that which Venel has employed, and I believe is the fame as that frequently employed by nature for the fame purpofe (§ XVI) : but in order to generate in water the proper neutral or middle falts, a more laborious and cautious management is neceffary ; as we are not in poffeffion of an eafy and commodious method of meafuring either the ftrength of the menftrua, or the quantities neceffary for faturating them.—The following is the method which I at firft employed :—

A B is a glafs veffel fomewhat (fig. ii.) more than half filled with water, and chalk coarfely powdered ; the tube A C D is fo fitted to the mouth of the bottle that not the leaft air can efcape. The tube E, in the fide of the bottle, is accurately clofed by the ftopper F, as foon as fome drops of vitriolic acid have been poured in : this acid, as foon as it falls, begins to expel the weaker aerial acid from the chalk ; which, rifing in the

form

form of an elaſtic fluid, is conducted by the tube to the bottom of the water in the veſ-ſel G H : this veſſel is choſen long and nar-row, that the aerial acid may be more com-pletely abſorbed in its paſſage through the water. A wet bladder is tied round the neck of the bottle G H, and the tube, ſo as to confine the aerial acid, which would otherwiſe eſcape; this reſiſtance, however, muſt not be too great, as in that caſe no aerial acid will be produced (on Aerial Acid, § 11): the eſcape of the aerial acid may therefore be regulated by a pin-hole in the bladder; as ſoon as the effervefcence ceaſes, more acid is to be poured in, through the tube E, and this repeated until the water has received the proper quantity of aerial acid, which may be determined by the taſte, or more accurately by tincture of turn-ſole. In this manner I firſt prepared aerat-ed water; but it may be done much more commodiouſly by the funnel o, which, ac-cording to Mr. Lavoiſier's method, is ſo ſhut by the glaſs rod P, that the vitriolic acid falls down ſpontaneouſly and gradually.— I ſometimes have employed a ſmall ferment-ing maſs (fig. vii. tab. 2.) and that with the beſt ſucceſs; but after I had learned, from the writings of Dr. Prieſtly, the advantage ariſing from agitating the water, I effected this purpoſe in two more eaſy ways.

(A) Fig. iv. will explain the firſt of theſe methods better than any verbal deſcription.

A B is a glafs bottle, fitted with a lateral tube, and a glafs ftopper; in this bottle an effervefcence is produced by means of chalk and vitriolic acid: E is a common glafs bottle, filled with the pureft water, and then ftopped by a cork, fo clofely that it cannot admit any air; it is then inverted, and fet in a groove, cut in the board G F, laid acrofs the veffel H I, filled with water; the cork is then taken out, and the aerial acid expelled by the vitriolic is conducted into the bottle by the tube A C D: the glafs tube L N O paffes through the cork: P Q is alfo made of glafs, and is fitted to the former by the intervention of the tube O P, which is made of elaftic refin, and tied to both (this might be made of flexible leather, but where the fides crofs, it muft be fewed only half through, otherwife the air will efcape through the holes made by the needle): the joint O P is made flexible, that the bottle A B may be fhaken, by which the extrication of aerial acid is much expedited; but this muft be done gently, left fome of the chalk fhould enter the tube A C, and mix with the water: for the fame reafon, only a fmall quantity of vitriolic acid is to be added at one time; for if too much be added, fo violent an effervefcence will be occafioned, as to carry over into the tube a quantity of the chalk: it is neceffary to obferve, that not the fmalleft cranny fhould be left open for the efcape of aerial acid, therefore the ftop-

per

per of the lateral tube muſt be cloſely fitted, and every part about the neck of the bottle A B, and tube, completely ſhut up : the extremity Q may be eaſily put in and taken out of the bottle, by the forceps, fig. vi.

The apparatus being prepared, I impregnate the water in the following manner :—I fill the bottle ſomewhat more than half with aerial acid ; this being done, I let fall to the bottom of the veſſel the ſaucer K ; I then cautiouſly remove the bottle from the groove in the board, keeping its mouth ſtill under the ſurface of the water, and ſetting its mouth upon the ſaucer K, I agitate it violently for ſome minutes ; during this operation the empty ſpace in the bottle diminiſhes, the water, by agitation, preſenting a larger ſurface of contact to the aerial acid, which is therefore more readily abſorbed ; the bottle, however, cannot be entirely filled the firſt time, as ſome portion of common air remains, which will not unite with water ; I therefore cork the bottle under the ſurface of the water, turn it up, and fill the empty ſpace with water ; I again invert the bottle in the water, half fill it again with aerial acid, agitate it as before, and then generally obtain it full.   As the water expelled from the bottle is diluted with that in the diſh, it is neceſſarily the leſs impregnated when it re-enters the bottle ; if therefore the water is to be ſaturated, in which proceſs it takes up nearly its own bulk

bulk (on Aerial Acid, IV.) the above-mentioned operation muſt be repeated a third time: and hence may eaſily be deduced a method of impregnating water in any given leſſer proportion.

It is in general to be obſerved, that the colder water is, the more aerial acid will it abſorb; therefore this operation ſhould be performed in a cool place, and the body of the bottle handled as little as may be.

I make uſe occaſionally of bottles of different ſizes, generally ſuch as contain half a kanne, but ſometimes (for expedition ſake) thoſe of 2, 3, or 4 kannes; but the larger are both inconvenient, on account of their weight, and are liable either to be broken themſelves or to break the ſaucer, unleſs handled with caution.

By this method a bottle of water may be ſaturated in about ten minutes: if the bottle, half filled with aerial acid, be ſuffered to ſtand inverted upon the board, the water will, in a cool place, riſe ſpontaneouſly without any agitation; but this will happen ſlowly, as before obſerved.

(B) The other method is much more eaſy, and impregnates a large quantity at one time, but is attended with this inconvenience, that it requires a very large fermenting maſs: when this can be had, let a veſſel be prepared, ſimilar to that in which the maſs is ſet to ferment, but of ſmaller diameter,

meter, fo that the veffel which holds the fermenting mafs may contain it ; let its height be fo adjufted to the empty fpace in the larger veffel, that, when the bottom of the leffer touches the fermenting mafs, its upper edge may ftand three or four inches at leaft beneath the upper edge of the larger veffel.

In the middle of this veffel let an axis be erected perpendicularly, fo that, by means of an handle, it may be turned round horizontally ; let there be faftened to this axis three or four wooden plates, fome inches broad, at feveral diftances from the bottom ; thefe muft be fhorter than the diameter of the veffel, with the plane of their furfaces inclined to the horizon in an angle of about 45°. The veffel being then filled with cold water, and fufpended over the fermenting mafs, fo as nearly to touch its furface, let the axis be turned round, and it will give a circular motion to the water; fo that by enlarging and continually changing the furface, the aerial acid is very quickly abforbed. —Thus a very large quantity of water may be completely faturated in a fingle minute.

§ XVIII. *Obfervations concerning the Addition of the Salts.*

The water being fufficiently impregnated with aerial acid, and poured into bottles, the materials determining the particular fpecies are next to be added : what thefe are, and in what quantity they are to be employed, will appear from the foregoing analyfis.

fis. The mineral alkali, and the other falts, fhould be chofen pure and newly cryftallized — the earths in a cryftalline form, fully faturated with aerial acid, and reduced to a very fine powder; for otherwife they diffolve flowly: iron is to be employed, in the form of frefh filings tied in a linen cloth, or that of a plate of convenient form, with a fmooth and polifhed furface: the cloth or plate is to be fufpended in the water, to promote the folution; the bottle is then to be well clofed, inverted, and fet in a cool place for fome days. In that fpace of time the water takes up the falts, and, by means of the aerial acid, not only diffolves the lime, but alfo a fmall portion of the iron. I know that the celebrated Monnet contends, that water can, by itfelf, take up iron; but common water always contains fome aerial acid; and when that is expelled not the fmalleft particle of iron is taken up by it, except that fpecies which, when red hot, is (*f*) brittle, as fuch always contains fome vitriolic acid.

(*f*) Such was the general fuppofition concerning the caufe of this fault in iron: but it was not founded on any accurate experiments; and when Profeffor Bergman came to inveftigate the fubject himfelf (de Analyfi Ferri, § VIII.) he could difcover no veftiges of vitriolic acid, by means of any teft. His experiments lead him to impute this defect to fome depravation of the inflammable principle. Hot-fhort iron (*calidum fragile*) affords inflammable air, which, when fired, fhews phænomena different from that which is obtained from other iron: it has a peculiar fmell, approaching to an empyreuma, and, when forged, emits more fparks. B.

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The fame filings will ferve repeatedly, provided the cloth, when taken out of the impregnated water, be plunged into cold water, and fuffered to remain there until ufed again : for when expofed to the air it contracts ruft, and thereby becomes infoluble; for the fame reafon the furface of the plate muft be polifhed afrefh as often as it lofes its fplendour.

By the method juft defcribed waters are obtained, agreeing both in flavour and virtue with thofe brought from foreign countries; but as fome of the fubftances contained are juftly efteemed of a fufpicious nature, I am of opinion that they fhould by all means be omitted : thefe are the calcareous and gypfeous matters; and I am perfuaded that no perfon will imagine that chalk or gypfum can contribute to the falubrity of waters; but that, on the contrary, they may give occafion to grievous obftructions. The Pyrmont water contains thefe fubftances in confiderable quantity, and for that reafon is hurtful to many conftitutions : for twelve kannes of this water (which is the quantity ufually taken in twenty-four days) contain half an ounce of aerated lime, and an ounce and a half of gypfum—a load which few ftomachs are able to bear.

As to the magnefia, I do not indeed confider it as noxious; but as it diffolves flowly, and whatever effect it has may be eafily

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supplied in another way, I omit it; especially as experience shews that the waters thus corrected are equal, if not superior, both in taste and virtue, to the natural waters.—I generally make use of water fully impregnated with aerial acid.

The imported waters which have been examined have no doubt suffered some change during the voyage. — The experienced Seip relates, that a phlogisticated vitriolic acid, and a true sulphur, may be extracted from the vitriolated magnesia of Pyrmont water, by distillation, without any addition. In order to obtain half a pound of this vitriolated magnesia (which is necessary for his experiment) we must evaporate upwards of 115 kannes of the water, which I have never had an opportunity of doing;—I have, however, tried smaller quantities, but never could discover the smallest particle of the substances he mentions:—perhaps the magnesia which is united with phlogisticated vitriolic acid in the fresh water, loses the inflammable principle during the voyage; so that, on its arrival in Sweden, it retains little or none of it; in the same manner as the sulphurated salt of Stahl changes by time into vitriolated vegetable alkali. This ingenious philosopher (Seip) to whom the aerial acid was unknown, contends, that the phlogisticated vitriolic acid is the true mineral spirit; that it adheres to the iron in Pyrmont water until exposed to the

the air; and that then, by means of a ftronger
elective attraction, it feizes the magnefia,
which it was not able to do in the clofe and
confined fubterraneous paffages.—This ex-
planation, though approved of by many, is
found, upon examination, to be quite con-
tradictory to fact;—for, let us fuppofe the
water loaded with a quantity of vitriol fuf-
ficient to generate 25 grains of vitriolated
magnefia, that is, containing 21 grains of
martial vitriol in three cubic inches of dif-
tilled water; let this water be put into a
bottle of fuch a fize that it will be quite
filled by the addition of 10 grains and an half
of magnefia, and let the bottle be then clofe-
ly ftopped; let this bottle be fhaken from
time to time, the magnefia will quickly dif-
appear, and in its place will be found a large
quantity of ochre, of a greenifh colour, as
containing both aerial acid and a confiderable
portion of phlogifton; and all this takes place
without any motion or effervefcence: in
the fpace of about an hour the water is found
totally void of vitriol, loaded with 25 grains
of vitriolated magnefia, faturated with aerial
acid, and containing an aerated iron:—the
reafon of this is evident, $10\frac{1}{2}$ grains of mag-
nefia contain about 3 cubic inches of aerial
acid, which an equal bulk of water is able
to abforb; no fuch obftacle therefore oc-
curs in this cafe, much lefs in a whole
kanne of water, as I have elfewhere men-
tioned. In the fame inftant, then, that

T   .the

the vitriolic acid expels the aerial, the water abforbs it. The quantity of vitriol employed contains above $4\frac{1}{2}$ grains of iron flightly calcined; now, 100 cubic inches of aerated water can only take up $3\frac{1}{2}$ grains, fo that 3 cubic inches of water can fcarcely diffolve more than $\frac{2}{100}$. The bottle being opened, the vitriolated magnefia may foon be feparated by alcohol; and this is the cafe in Pyrmont water: the phlogifticated, as well as the common vitriolic acid, feparates the aerial acid from magnefia.—All this hypothefis, therefore, falls to the ground, being void of foundation;—and Pyrmont water, expofed to the air, grows turbid, and lofes its virtue, not on account of any tranfpofition of its principles, but on account of the departure of the volatile menftruum.

In the dry way, vitriolic acid with phlogifton, generates fulphur; but whence can fo much phlogifton be joined with the vitriolated magnefia in Pyrmont water?—if the feparated iron ftill remains mixed with it, the difficulty is eafily removed, as this metal, when flightly calcined, ftill retains much phlogifton: if, after the removal of the iron, fulphur is produced, the caufe of this phænomenon, being obfcure, fhould be examined in the country where the water is produced.

§ XIX. *The*

§ XIX. *The Preparation of artificial medi-
cated Waters in Sweden.*

In the year 1770, being attacked by a fe-
vere hæmorrhoidal colic, I was obliged to
take above eighty bottles of foreign medi-
cated waters. · By thefe the fymptoms,
which were attended with excruciating pain,
were fomewhat mitigated ; in the mean
time I examined the nature and principles
of thefe waters with the greateſt attention,
as I moſt earneſtly wiſhed to be able to
imitate them perfectly ; for befides their
extreme dearnefs in this country, in the be-
ginning of fpring, when not only difeafes,
the foundations of which have been laid dur-
ing the feverity of the winter, prevail very
much, but my complaints are alſo particu-
larly troublefome, thefe waters cannot be
had freſh and good at any price.—I foon
reaped the wiſhed-for fruit of my labours,
for in the year following I fubſtituted the
artificial to the natural waters, and not only
ufed them myſelf with fignal advantage, but
gave them to many of my friends with the
like fuccefs. All that time I ufed the method
above defcribed for impregnating water with
fixed air ; but, in the year 1773, I learned
Dr. Prieſtly's method, which, with a little
alteration, I have fince continued to practife.
—The fame year, in a ſhort Treatife on the
Aerial Acid, which the Royal Academy of

Sciences

Sciences at Stockholm inferted in their Acts, I mentioned in a curfory way that I had for fome time prepared for myfelf and fome of my friends artificial medicated waters, entirely refembling the natural waters, both in flavour and virtue.—The celebrated Baer, who then lived at Paris, took that opportunity of writing to my friend Mr. Wargentin, requefting me to defcribe the method I purfued.—This I complied with, by fending a Treatife on that fubject to the Royal Academy of Sciences at Stockholm in 1774, which they inferted in their Acts for the following year.

From the very nature of the thing it muft be obvious, that an invention of this kind, however ufeful, cannot poffibly be univerfally pleafing.—Many who are incapable of afcertaining or judging of the truth, will diftruft it, not without reafon, on account of its novelty;—many contend, that to imitate nature is impoffible, without confidering, that when the component parts are thoroughly known, the fuccefs of the procefs cannot in any degree depend upon the hand which combines them.—Some who prefcribe, and others who fell the foreign waters, condemn the artificial, for obvious reafons; and not a few are urged by motives too trivial to be detailed. Befides, the negligence of inexperienced operators or impure materials, may eafily defeat the whole operation. The water itfelf, if it has any

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offenſive taſte, will retain it after the proceſs, and by that means bring the invention into diſrepute. Thoſe that are prepared in the very beſt manner, nay, the natural waters themſelves, grow vapid on the addition of a ſmall quantity of mineral alkali, though they ſtill retain uſeful properties, only the pungency of the aerial acid is in this caſe repreſſed.

All theſe obſtacles, however, have not prevented the preparation and ſucceſsful uſe of artificial medicated waters, even in the moſt diſtant provinces of Sweden; and the uſe of ſuch waters has prevailed generally, although I only propoſed them in caſes of neceſſity, where the natural waters could not be had : and even thoſe who at firſt could not patiently hear them mentioned, now make uſe of them, and highly commend them.

In general they produce the ſame good effects as the natural waters, and in ſome inſtances even ſeem to excel them : my own health, though not perfectly eſtabliſhed, has, from the ſole uſe of them, been reſtored beyond expectation. Every year, about the middle of winter, the beginning of ſummer, and in autumn, I uſe about ſeven kannes in the ſpace of three weeks, and that in the following manner :—I firſt drink a few kannes of Seltzer water, I then uſe the Spa, which, with reſpect to the uncombined alkali, moſt nearly reſembles the Seltzer, and I always finiſh with the Pyrmont; I take no more

than

than the third part of a kanne every day, as, by the experience of feveral years, I have found that a larger quantity is difagreeable to my ftomach.

I have alfo feen, with great pleafure, many other complaints either entirely removed, or at leaft alleviated, by thefe means. A circumftance, which afforded me fingular pleafure, as I had very anxioufly wifhed to fucceed in this experiment :—a boy of feven years old, at Upfal, had for fome time been afflicted by a violent gout, which had baffled all remedy; in the year 1775 he ufed for a month the Seltzer water, prepared for him by his father, according to my inftructions, and foon recovered perfect health, which he enjoys to this day.

A young gentleman, a ftudent, about 23 years old, was fo afflicted by the gout, that he could not, even by the help of a ftick, move from one feat to another : he began the ufe of the artificial waters, firft Seltzer, then Pyrmont, and recovered in the fpace of one month.

Befides, the intermittent fevers, which for fome time paft were epidemic in Sweden, were fo obftinate, that they refufed to yield either to Peruvian bark, or the other ufual remedies, but were foon removed by the artificial waters, particularly Seltzer, unlefs the cure was impeded by errors in diet.

I pafs over innumerable other examples, which, indeed, encreafe daily, and would re-
quire

quire a particular defcription ; but I cannot
avoid here mentioning a fingular phænome-
non :—the hæmorrhoids, with which I am
afflicted, break fpontaneoufly, while I am in
health, generally every 20th day, but only
difcharge a few drops ; they are, however,
often ftopped, efpecially at the approach of
cold weather, and then occafion a number
of diftreffing fymptoms : to remedy thefe
I find nothing fo effectual as drinking the
artificial Seltzer water ; and in the courfe of
eight years, during which I have been ufing
it, it never failed me once ; the effect is,
to open the hæmorrhoids within fix days,
fometimes on the third or fourth, upon
which I immediately find relief.—I leave
to the fkilful in medicine the explana-
tion of this phænomenon, which I have
obferved not only in myfelf, but in many
others affected in the fame way, to whom I
recommended it to pay fome attention to
this circumftance.   Now, as the fame ef-
fect in this cafe follows the ufe of the
natural and the artificial Seltzer water, I
cannot doubt of their identity, any more
than of that of the others.

DISSERTATION VII.

OF THE

ARTIFICIAL PREPARATION

OF

HOT MEDICATED WATERS.

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§ 1. *Different Species of hot Waters.*

THE benign care of our all-wife Creator has not only provided for man's ufe cold medicated waters, but many hot medicinal fprings are found in various parts of our globe; and as the ufe of the former is found not to be reftricted, but extenfive and widely diverfified, fo in like manner the latter are endowed with a great number of ufeful properties. Some of thefe hot waters feem to poffefs no remarkable virtue with regard to the human body, while others quickly difpel a variety

of

of difeafes in a very fingular and extraordi-
nary manner. Water does not feem capable
of producing any notable effect upon the
human body of itfelf; to this end it appears
indifpenfably neceffary that it fhould be im-
pregnated with a certain fubtile and elaftic
aura, which, when extricated in the primæ
viæ, is not only of itfelf able to effect falu-
tary changes, but alfo fo acuates, ftrength-
ens, and as it were vivifies, the heteroge-
neous matters contained in the water, that
they can penetrate to parts they otherwife
could not reach, and poffefs powers which
alone they could never exert. That the
aerial acid performs this office in the cold
medicated waters is, I imagine, eftablifhed
beyond doubt in the foregoing Treatife;—it
remains now to be examined, whether the
fame fluid is contained in the hot waters, or
whether they are affifted by an elaftic fluid
of another kind.

When we examine the medicinal hot wa-
ters in general, we find a remarkable differ-
ence obvious to the fenfes: for fome, fuch
as the Caroline baths in Bohemia, do not
ftrike the fmell in any particular manner,
and feem not to exhale any thing more than
a moift and fuffocating vapour; others,
fuch as thofe of Aix, difperfe far and wide
a moft fubtile, ungrateful, fetid odour, re-
fembling that of putrid eggs, or more ex-
actly that which is emitted by a folution of
faline hepar, efpecially upon the addition of

an

an acid. The former moſt certainly derive
their efficacy from the aerial acid, and are
therefore juſtly called aerated ; but the lat-
ter are of a very different nature, and may,
from their hepatic ſmell, not improperly be
called hepatifated. The nature and pro-
perties of both muſt be accurately examined,
if we expect to attain any thing like exact-
neſs in the imitation of them. They both
contain a principle ſo volatile that they loſe
their chief virtue upon barely growing cold ;
ſo that by no means yet known can they
be tranſported into foreign countries, ſtill re-
taining their virtue. This circumſtance has
prevented me from examining theſe hot wa-
ters myſelf : but ſo much as will be ſuffi-
cient for our preſent purpoſe is to be found
accurately inveſtigated, and clearly related,
by the induſtry of others.

§ II. *Hot Aerated Waters.*

That the Caroline waters, and others of
the ſame ſort, abound with aerial acid, may
be inferred from their taſte, and the quan-
tity of bubbles which is occaſioned by agi-
tating them : but other and more obvious
criteria ſhew this evidently to be the caſe.
This water tinges tincture of turnſole with a
fugitive redneſs, and precipitates lime-wa-
ter ; circumſtances which, though ſingly
ambiguous, yet jointly are perfectly valid ;
— they are ambiguous ſingly, becauſe it is
                                        thought

thought that other acids, befides the aerial, may occafion a fugitive rednefs (*a*) ; and the precipitation of lime-water is alfo oc- cafioned by an aerated alkali, which is fup- pofed, according to the laws of attraction, to yield its aerial acid to the pure lime, which therefore becomes aerated, and (*b*) precipitates ; but when thefe two circum- ftances are taken together, they produce full conviction : for the aerated alkali (*c*) cannot exift in water together with any acid, ex- cept the aerial ; befides, the air contained in thefe waters, when collected, not only produces the above-mentioned effects, but alfo fuffocates animals, and is abforbed by water, which thence becomes aerated. In- deed, the whole neighbourhood of thefe wa- ters abounds fo much with aerial acid, which breaks out in many places, that the rain and fnow-water, from lying in cavities of the ground for a fhort time, often acquire a grateful pungent acidity.

These waters, upon cooling, feparate both lime and iron, after the manner of Pyrmont water, but much more quickly. We cannot wonder at the fugitive nature of the virtues of thefe waters, when we confider how very volatile the aerial acid is, even when lodged in cold water, and how much its volatility is increafed by heat.

(*a*) On Aerial Acid, § VI.
(*b*) Ibid, § XX. B.
(*c*) Analyfis of Waters, § VIII. D.

The

The exiftence of aerated hot waters being eftablifhed, we now go on to the other fpecies, the elaftic fluid of which, though eafily diffipated, yet in fixity very much exceeds the aerial acid.

§ III. *Hot hepatifated Waters.*

The hot hepatifated waters, although they may be aerated, and actually often are fo (as for inftance thofe of Aix) may yet be eafily diftinguifhed from the hot aerated waters, by the general tenor of their character, and their difagreeable fmell : they have the fmell of hepar fulphuris, and blacken filver, nay, a genuine fulphur is depofited along the channels through which they pafs; and yet the moft accurate analyfis has not been able hitherto to difcover in the water the moft minute particle, either of hepar or of fulphur—but chymiftry is able to unfold this myftery : for the faline hepar fulphuris, upon the addition of a more powerful acid, generates a fpecies of air, which we may call hepatic air, if with Dr. Prieftly we give the name of air to every elaftic fluid not condenfible by cold. Waters impregnated with this kind of air refemble the hot hepatifated waters : the hepatic air, it is true, contains a fulphur, but fo expanded and fubtilized as to efcape the fight, and put on the appearance of common air. A change fuch as this can only be effected by the action of agents at once the moft fubtile and the moft efficacious,

2

cacious,

cacious, and such are phlogiston and the
matter of heat. I know that many philo-
fophers of the firft rank are of opinion,
that the phænomena of fire and heat are to
be explained upon the fuppofition of intef-
tine motion in bodies ; but, upon confider-
ing the whole attentively, I am firmly per-
fuaded, and I believe the fame is the cafe
with others, that heat arifes from the action
of a diftinct and peculiar fubftance, which
is diftributed through the whole corporeal
world, and that in a twofold ftate : for,
firft, we confider this matter as free, when,
in form of an elaftic fluid continually tend-
ing to an equilibrium, it pervades all bodies
denfe as well as rare. This, in proportion to
its quantity, excites different degrees of heat
in animals, dilates and difpofes all bodies to
fluidity, according to certain circumftances
—thus platina, in order to be fufed, requires
it very highly concentrated, other metals
lefs fo ; and mercury a quantity fo fmall
that it is almoft always prefent in the atmo-
fphere ; I fay, almoft always, as fome late
obfervations in Siberia fhew that there mer-
cury has been fometimes congealed by natu-
ral cold :—whether there can exift any fuch
ftate as that of perfect privation of heat, or
abfolute cold, is yet unknown. In fuch a
ftate (fuppofing any fuch to exift) if I mif-
take not, the aerial acid itfelf muft be con-
gealed, as fluidity appears to depend totally
upon heat.

The

'The matter of heat, like all other mate-
rial fubftances, is fubjected to the law of at-
traction, and hence proceeds its ftate of
union with other bodies, a ftate which ine-
vitably occafions many alterations in its na-
ture and properties : by this tie fome of its
properties are obfcured, nay, entirely obli-
terated, and new ones, before unknown, are
produced ; and in the fame manner as an acid,
when faturated with an alkali, cannot be
diftinguifhed either by precipitation, by its
tafte, or by any other of its original proper-
ties, fo the matter of heat lofes, together
with its liberty, its chief property, *viz*.
that of producing fenfible heat ;—this power
muft, however, be confidered as repreffed
only, not deftroyed, for it is again reftored in
full vigour, when the bond of union which
repreffed it is broken. This may very clearly
be illuftrated by the example of water, which
by a moderate privation of heat is convert-
ed into ice: now if water heated to a determi-
nate degree be poured on fnow, we can, from
the known heat of the two ingredients eafily
determine what that of the mixture ought to
be ; but in the prefent inftance, a deficiency
is always obferved, that is, the heat of the
mixture proves to be always lefs by about
72°, than by calculation it ought to be. The
reafon feems to be this:—the heat of the wa-
ter penetrates the fnow quickly, expands and
feparates the fmall particles, and changes

it

it from a folid to a fluid form; thus the dif-
united particles have their furfaces much en-
creafed.   Now water attracts the matter of
heat, and that the more largely in proportion
to the furface of contact; and fuch parts of it
as it touches very clofely it powerfully re-
tains, and renders latent, fo that it can no
longer occafion fenfible heat; and hence the
deficiency of 72°.   This faturating portion
of heat it does not lofe, except at the very
point of congelation, which being then fet
free occafions a fmall rife of the thermo-
meter, although it is quickly and irregu-
larly attracted on account of the deficiency
of the furrounding matter.   As the degree
of cold in the adjoining air increafes, and
as, on account of its elaftic nature, it con-
ftantly tends to an equilibrium, it at length
is fo much rarefied that the faturating por-
tion alone remains to prevent the contact of
the watery particles; and when that alfo is
taken away, all the mobility of the particles
totally ceafes: undoubtedly all fubftances
which are fufible in fire fix a certain quan-
tity of heat (the degree of which is yet un-
determined) in the very inftant when their
particles acquire the due degree of mobility.
On the other hand, while the tempera-
ture of the water is increafing the increafed
quantity of heat increafes the diftance of the
minute particles, and generates elaftic va-
pours; at length when the heat arrives to
the boiling point, the watery particles are

10   fo

fo expanded and changed, that their furfaces, being wonderfully increafed, are enabled to receive and fix a far greater quantity of heat than before ;—and hence arifes the cold, or diminution of heat, occafioned by evaporation.

Bodies which contain the matter of heat fixed, when put into menftrua fitted for diffolving them, generate a degree of heat, greater or lefs, according to the quantity of latent heat fet at liberty by the more powerful attraction of the menftruum. Lime, newly burned and put into water, generates a remarkable degree of heat, becaufe a great part of the heat which had been fixed by the calcareous earth is fet at liberty by means of the water, which is more powerfully attracted by it. That portion of the matter of heat which ftill remains in flaked lime may be difengaged by an acid ; and hence, from an equal quantity of lime a greater degree of heat is generated with acids than with water, as the former fet the whole of the matter of heat at liberty, the latter only a part.—I have fpoken briefly, and in a curfory way of thefe matters, in order to illuftrate feveral things in the foregoing pages ; and that what follows may be the better underftood. We do not here confider the compofition of the matter of heat ; it is fufficient for us that it may be fixed, and again fet at liberty.

Let

Let us now return to the hepatic air, which confifts of fulphur united to the matter of heat by means of phlogifton. As the demonftration of this analyfis occurs hereafter, I pafs it over in this place. The hepatic air is decompofed in the atmofphere by means of pure air, which attracts phlogifton fo greedily, that it is able to feparate it from the nitrous acid itfelf : this is the caufe of the fulphureous crufts which are to be feen at Aix ; for the connecting medium (the phlogifton) being feparated above the furface of the water, the whole compound is diffolved, and the difengaged particles of fulphur adhere to the furrounding bodies.

Water combines with this hepatic air, and when impregnated with it poffeffes the genuine properties of hepatifated waters, as readily appears upon comparifon : but in order to difcover how much of its virtues depend upon this air alone, and how much upon groffer materials, we fhould examine diftilled water faturated with hepatic vapour. — In a moderate heat, a kanne of diftilled water takes up about fixty cubic inches of hepatic air, which, when decompofed by nitrous acid, yield 8 grains of fulphur: the matter of heat which remains difengaged among the particles of the water, is more and more diminifhed.

U   § iv. *Dif-*

§ IV. *Diſtilled Water ſaturated with hepatic Air.*

In the following ſection we ſhall explain how water may be ſaturated with hepatic air. For the preſent we ſuppoſe the water to be cool, and fully ſaturated.

(A) It has a moſt offenſive hepatic ſmell, when ſet in a broad open veſſel; in 24 hours it blackens ſilver; an effect which, as the vapour is diſſipated in this caſe but ſlowly, it does not produce in leſs than the ſpace of ſome weeks, when ſet to ſtand in an open bottle. This effect may be inſtantly re-preſſed by nitrous acid.

The taſte is ſtrong, ſomewhat ſweetiſh, not unlike that of putrid eggs, but more diſagreeable.

It preſerves its clearneſs entirely, if the wa-ter be newly diſtilled, ſo as not to have time to abſorb aerial acid from the atmoſphere.

(B) Tincture and paper of turnſole grow but little red, unleſs the water be impreg-nated with waſhed hepatic air.

Paper of fernambucum ſuffers no change.

(c) No change is occaſioned by acids, unleſs ſuch as poſſeſs the ſingular property of attracting phlogiſton, even in water; one of theſe is the nitrous acid highly concen-trated.—When this is dropped in, the ſmell is inſtantly ſuppreſſed, the water grows tur-bid, and a white ſubtile powder very ſlowly

2   ſubſides:

subsides : this powder, collected and dried, is found to be pure genuine sulphur. The phlogiston being taken away by the acid, the bond of union between the sulphur and the matter of heat is broken; the hepatic air is therefore decomposed, and the sulphur appears in its ordinary form. That the nitrous acid attracts phlogiston, even in a liquid, is obvious from the artifice made use of by some to make vitriolic acid, when black, clear again, — they add a small quantity of nitre, which is speedily decomposed, and the colouring phlogiston destroyed by the disengaged nitrous acid.

Upon pouring into the impregnated water a few drops of nitrous acid, the fætor is instantly stopped, but in a few minutes it again returns, and this happens repeatedly; so that a quadrant of water requires 200 drops to destroy completely all its hepatic air. When the water contains also a fixed alkali, the acid has but little effect, so long as that is disengaged, but after it is saturated the hepatic air begins to be decomposed; the reason is clear :—the alkali seizes the acid as soon as it is dropped in, and represses its activity; hence we easily see how sulphur may be precipitated from the Aix waters, which no one, so far as I know, has hitherto effected.

Acid of vitriol, and the other common acids, have no effect.

Dephlo-

Dephlogifticated marine acid precipitates the fulphur.

(D) Alkalis caufe no change.

(E) Nitrated filver occafions a congrumation, which foon changes to a brown colour. —In this cafe the acid and the metallic bafe feem to be loaded with phlogifton, by which they are both rendered infoluble : there is no doubt but a fulphur alfo adheres to the metal.—Silver, in its metallic ftate, grows black in this water.

(F) Nitrated mercury, made without heat, occafions a brown precipitate ; that made with heat, a white one. The difference feems to arife hence, that in the latter cafe the bafe is fo far dephlogifticated that the phlogifton remaining is infufficient for communicating colour to the precipitate.—Mercury, in its metallic ftate, expofed to hepatic air, grows black, like filver.

(G) Corrofive fublimate is alfo precipitated white, for the above-mentioned reafon.

(H) Acetated lead is precipitated black.— Vinegar does not promote the decompofition of hepatic air : hence, therefore, appears the action of the metallic bafe alone ; —yet polifhed lead, expofed to hepatic air, does not grow black, but only brown. The fame is true of iron : copper grows black ; but tin, bifmuth, antimony, and zinc, are not changed.

(I) Solution of vitriol of zinc occafions a little turbidnefs, and yields a white fediment ;

ment ; that of copper occafions a yellowifh brown hue, and flowly depofits a fediment of the fame colour ; that of iron grows black :—the hepatic fmell is foon diffipated, if the proportion of the liquors be properly adjufted.

(κ) A grain of white arfenic put into the water grows yellow by degrees, and at length acquires the properties of orpiment. The fame thing happens to a folution of arfenic in water.

(l) Hepatifated water, in which filings of iron have been kept for fome days in a well-clofed veffel, grows purple with tincture of galls ;—if the iron be diffolved by an acid, the colour approaches more to violet. This is the reafon why, with the fame quantity of tincture of galls, different appearances take place : befides, we muft obferve, that water impregnated with iron by means of hepatic air, is not at all rendered turbid by phlogifticated alkali ; and if a fmall quantity of vitriol of iron be afterwards added, this produces a fediment at firft afh-coloured, the upper furface of which grows by degrees (but very flowly) of a pale blue, and after fome days grows quite black. If hepatifated martial water grows immediately blue on the addition of phlogifticated alkali, this is a fure fign of the prefence of an acid menftruum. Thefe circumftances fhould be carefully obferved in the examination of waters.

§ v. *Method*

§ v. *Method of preparing hot medicated Waters.*

In the preparation of hot medicated waters feveral circumftances are to be attended to :—firft, the waters muft be impregnated with elaftic fluid ; then the groffer materials, which diftinguifh the different fpecies, are to be diffolved ; and, finally, the water to be heated without any lofs of its virtue.— We fhall fpeak of all thefe in order.

(A) The elaftic fluid to be employed is either aerial acid or hepatic air, according as the water is required aerated or hepatifated. The former is obtained by a procefs already fufficiently defcribed ; the latter is had in the fame way, with the difference of a few circumftances now to be mentioned.

In the place of chalk we are to employ an hepar fulphuris made of equal weights of fulphur and pot-afhes together, and melted in a crucible : the hepar is to be reduced to a powder before it is put into the veffel, as otherwife the faturating acid will generate upon the furface a vitriolated vegetable alkali, which is not foluble in a fmall quantity of water ; and this cruft, furrounding the internal parts, will prevent the acid from reaching them.—A mafs made of three parts of iron filings melted, with two of fulphur, anfwers the fame end, even better than the former.

An

An inverted bottle, half filled with water, is to be fet to collect the extricated elaftic fluid: the water cannot take up fo much of hepatic air as it does of aerial acid;—if the water is to be aerated at the fame time, $\frac{1}{3}$ or $\frac{1}{4}$ of chalk may be added to the hepar. When, upon agitating the bottle, the hepatic air is no longer diminifhed, the water is faturated.

The vapour being extremely offenfive, and unfriendly to refpiration, the operator fhould be fo fituated that a ftream of air may carry off the noxious vapour from him.

(B) If particular waters are to be imitated, for inftance, the Caroline or the Aix waters above-mentioned, the quantity and quality of their feveral contents muft be determined. The Caroline waters contain, in a kanne,

	grains.
of aerated lime - -	24
of vitriolated mineral alkali	240
of fea-falt - -	32
of dried mineral alkali -	68

together with an admixture of iron. A kanne of Aix water, taken from the emperor's bath, contains,

	grains.
of aerated lime - - -	27
of fea-falt - - -	29
of mineral alkali - -	70

It

It is only the aerated lime that indicates the prefence of aerial acid in the Aix waters.

Thefe heterogeneous matters, except the aerated lime (which ought by all means to be left out) are of very eafy folution; they need not therefore be added to the water, until it is to be drank: the proper quantities of thefe may be put into the veffel out of which the water is to be drank, and are foon taken up by the warm fluid.

If any one, however, infifts upon the aerated lime, the water muft firft be faturated with aerial acid, and the lime diffolved by its means, in the cold, as before defcribed; the water is then to be impregnated with hepatic air; and in this cafe fome filings of iron fhould be added: but if the lime be omitted, the filings put in during the warming of the water will give it a fufficient impregnation.

(c) in order to make the aerated or hepatifated water warm, without lofs of virtue, we muft employ a veffel clofely fhut, fuch as Papin's digefter;—the copper ones defcribed by Mr. Wilcke are beft fitted for this purpofe: one of thofe fhould be taken, which can juft hold the requifite quantity of water: the aerated or hepatifated water being put into this, and well clofed up, is to be fufpended in a common pot in a water-bath; and the water in the greater veffel, being gradually heated, communicates the requifite degree of heat to the digefter.

Although

Although cold aerated water is highly medicinal, as experience evinces; and although the fame is unqueſtionably true of cold hepatiſated water (§ vi.); yet it is very probable that heat, by encreaſing their volatility, renders them more ſubtile and penetrating, and of conſequence more efficacious in certain caſes.   We are not yet certain what degree of heat is moſt effectual : the Caroline waters raiſe the Swediſh thermometer to 73°, the Aix waters to 62°; an heat which appears too great for internal uſe, as the hand can ſcarcely bear water heated to 50° : but this queſtion is not to our preſent purpoſe, it is ſufficient that the water can receive the neceſſary degree of heat, without loſs of virtue.

The ſaline matters ſhould not be put into the digeſter, as many of them act upon the metal, but the iron may ſafely be uſed; and thus it communicates a chalybeate impregnation.

That a glaſs may be occaſionally filled without the loſs of any of the volatile parts, a ſmall ſtopper muſt be fitted to the upper part of the digeſter, by opening which the warm water may be poured out, and yet the maſs remain cloſely ſhut up.

For the purpoſes of bathing, larger quantities are neceſſary; in this intention the Caroline waters (for what reaſon I know not) are out of uſe.   The waters of Aix are often employed; and a large quantity of water

may

may be eafily impregnated with hepatic air,
by means of a flexible tube conveying the
air to the bottom ; and this operation may
without inconvenience be continued, even
while the patient fits in the bath ; but the
procefs fhould be fo conducted as to affect
refpiration as little as may be.

§ VI.   *Appendix, concerning cold hepatifated
Waters.*

Cold martial waters, when frefh, almoft
always have an hepatic fmell, efpecially when
a little fhaken in a clofed bottle, yet in ge-
neral the impregnation is fo flight that it
goes off in a few moments ; but I have
lately learned that the hepatic impregnation,
in fome inftances, is more complete. Mr.
Alftroemerer fent me 12 kannes of Medway
water, requefting me to examine their con-
tents. Thefe acidulous waters are fituated
at Medway, in Oftro Gothland, and have
been celebrated for wonderful cures, from
the moft remote periods of time : the ce-
lebrated U. Hierne difcovered them in the
year 1677, from which time they have been
much frequented every year, and with con-
fiderable advantage ; yet their true nature and
properties are but little known.—The fol-
lowing experiments will tend to throw light
upon this fubject.

This water, when brought to Upfal, is
found to have loft its volatile principles, but
Dr. P.

Dr. P. Dubb examined it at the very fountain, by the means above defcribed: — he obtained from every kanne 13 cubic inches of an elaftic fluid, which diftinctly reddened tincture of turnfole, and therefore undoubtedly was aerial acid. That it alfo contains fome hepatic air, will clearly appear from what follows; but thefe 13 cubic inches, having been collected by means of water, do. not indicate the true quantity; and I doubt not but that, if they had been collected by mercury, they would amount to 30 at leaft.

In the Medway water there cannot be any pure air, as that is inconfiftent with a martial folution; but the hepatic air remained in the refiduum of 10½ kannes, reduced by evaporation, at the very fount, to nearly 2 quadrants : this apppears manifeftly, for the bottle in which the liquid refiduum was put, when opened, ftruck the nofe with an offenfive hepatic odour; and a portion of this liquor, upon the addition of a few drops of concentrated nitrous acid, grew white and turbid, and in 24 hours depofited a very fubtile fulphureous powder :—in this cafe then, we have a cold hepatifated water, which retains that fetid principle fo tenacioufly, that notwithftanding continued boiling, and the agitation of a long journey, it yet retained a confiderable portion of the volatile aura.

In

In order to difcover the fixed principles, I firft employed precipitants ; but I muft obferve, that the water fent to me was fomewhat yellow, very faintly indeed, yet fenfibly fo, efpecially when compared with common water : in the liquid refiduum, that colour was more confpicuous, and the refiduum itfelf nearly turbid.

In tafte and fmell it refembled pure water, but the liquid refiduum gave flight tokens of iron and of an hepar.

Papers tinged with turnfole or Brazil wood difcovered nothing ; hence it would appear that there is no prevalence either of acid or alkali.

Phlogifticated alkali caufed no change either in the water or in the liquid refiduum ; and this was the cafe at the very fountain (§ iv. l).

Tincture of galls alfo had no effect on the water, but with the refiduum formed a dilute purple colour, which yet was fomewhat changed by the yellowifh brown of the water itfelf.

Acid of fugar did not occafion a turbidnefs in the water, until after the fpace of 24 hours ; but with the refiduum immediately formed a faccharated lime.

Aerated fixed alkali does not make the water turbid, but it inftantly acts upon the refiduum ; the precipitate was white, and of a calcareous nature.

Salited

Salited terra ponderofa did not precipitate any thing, even in the refiduum; there is of courfe no vitriolic acid prefent.

A fmall piece of alum was decompofed after fome hours, which is no doubt occafioned by a falited lime, mixed with the alum.—Hepatic air does not act at all upon folution of pure alum.

A folution of nitrated filver renders the water fomewhat turbid; but in the refiduum it occafions a complete milkinefs, tinged lightly brown by the hepatic air;—there is prefent, therefore, a marine acid.

Nitrated mercury, prepared without heat, as alfo acetated lead, exhibit the very fame appearances as nitrated filver.

Corrofive fublimate has no effect.

Thefe experiments detect nothing but a fmall portion of falited lime, except the admixture of iron, which the tincture of galls fhews.

I evaporated half a quadrant of the liquid refiduum to drynefs, but found only 5 grains of a brown powder, which grew a little moift in the air, yet only a grain or two of it was foluble in water; fo that the greateft part of this was a calcined iron. Water poured upon the dry refiduum grows brown, an appearance occafioned by a mucilaginous extract; for, evaporating again to drynefs, it exhibits a brown matter, which grows white by burning. Since, then, 10½ kannes yielded two quadrants of this liquid refi-

duum,

duum, it appears, that we fhould allow about two grains to each kanne; for the fa-lited lime amounts fcarcely to half a grain: I have alfo obferved a few particles of fea-falt.

The dry refiduum which, according to Dr. Dubb's experiments, is obtained from each kanne by boiling for an hour, weighs 2, 75 grains, which feems to be purely martial; and it is to be obferved, that part of it is magnetical;—this property is, be-yond doubt, communicated by the hepatic air.

We conclude, therefore, that a kanne of frefh Medway water contains,

	grains.
of iron, partly diffolved in hepatic air, and partly in aerial acid	$4\frac{1}{4}$
of falited lime	$\frac{1}{2}$
	$4\frac{3}{4}$

	cubic inches.
of aerial acid nearly	30
of hepatic air, at leaft	40

The fea-falt, and mucilaginous extract, are of fo little weight, that they may in this computation be neglected.

This water muft neceffarily be very effi-cacious: for, 1ft, it contains united two principles, one of which gives virtue to the

hot,

SYNOPTICAL TABLE

OF ALL

The SUBSTANCES contained in the several WATERS examined, except those of UPSAL,

REDUCED TO

ENGLISH WEIGHTS, MEASURES, AND INSTRUMENTS.

Substances contained in the Pint, Winchester Measure, containing 35,25 Cubic Inches.

NAMES of the WATERS.	Physical Qualities.			Cubic Inches.			Grains.										
	Tempe-rature.	Weight.	Specific Gravity.	Pure Air.	Aerial Acid.	Hepatic Air.	Aerated Lime.	Aerated Magnesia.	Aerated Min.Alk.	Aerated Iron.	Sulphur.	Vitrio-lated Lime.	Vitrio-lated Magnesia.	Vitrio-lated Min.Alk.	Salited Lime.	Salited Magnesia.	Salited Min.Alk.
Distilled Water	—	Grains. 8923.8961	1.0000	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Snow Water	—	8924.7884	1.0001	—	—	—	—	—	—	—	—	—	—	—	—	82.7640	303.3954
Sea Water, at the Depth of 60 Fathom	—	9193.7956	1.0289	—	—	—	—	—	—	—	—	9.801	—	—	—	4.73714	—
Aerated. Seydschutz	—	8977.4393	1.0060	0.4356	0.8712	—	0.9801	2.7225	—	—	—	5.336	187.0991	—	—	—	13.7491
Aerated. Seltzer	—	8948.9905	1.0027	0.2178	13.068	—	78.38114	6.3251	5.2272	—	—	—	—	—	—	—	0.2178
Aerated. Spa	—	8932.8199	1.0010	—	9.801	—	1.8513	4.356	1.8513	0.70785	—	—	—	—	—	—	1.5246
Aerated. Pyrmont	—	8950.1335	1.0024	—	19.602	—	4.356	9.801	—	0.70785	—	8.3853	5.445	—	—	—	—
Aerated and Hepatic. Medway	—	—	—	—	6.534	8.712	—	—	—	0.92565	—	—	—	—	0,1089	—	6.2162
Hepatic. Aix la Chapelle	142°	—	—	—	—	13.068	5.9806	—	15.246	—	1.7424	—	—	—	—	—	—
Hepatic. Caroline	164°	—	—	—	—	13.068	5.2272	—	14.8104	—	1.7424	—	—	52.272	—	—	—

hot, the other to the cold medicated waters :
2d, it contains nothing noxious.——We know
that many waters, even the fo much cele-
brated Pyrmont, are loaded with aerated
lime and gypfum, fubftances which are by
no means friendly to the human fyftem ;
and the experience of a whole century
abundantly confirms this opinion of the
virtue of the Medway waters, which we
have deduced from analyfis.

How this water may be imitated, is eafi-
ly feen from what has been already faid.

DISSERTATION VIII.

OF THE

ACID OF SUGAR.

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§ 1. *Method of obtaining the Acid of Sugar in a separate State.*

SUGAR being juſtly conſidered as an eſ-
ſential ſalt, it will readily be granted,
that it contains an acid ;—this acid may be
ſeparated, and exhibited in a cryſtalline form,
by the following proceſs :—

(A) Let one ounce of the pureſt ſugar,
in powder, be mixed, in a tubulated retort,
with three ounces of ſtrong nitrous acid,
whoſe ſpecific gravity is nearly 1, 567.

(B) When the ſolution is completed,
and the moſt phlogiſticated part of the ni-
trous acid has flown off, let a receiver be
luted on, and the ſolution gently boiled ;—

in

in this procefs an immenfe quantity of nitrous air is difcharged (*a*).

(c) When the liquor acquires a dark brown colour, let three ounces more of nitrous acid be poured on, and the boiling continued until the coloured and fmoking acid has entirely difappeared.

(D) Let the liquor in the receiver be then poured into a larger veffel; and, upon cooling, fmall quadrilateral prifmatic cryftals are found adhering together at an angle generally of about 45° : thefe, collected and dried on bibulous paper, weigh 109 grains.

(E) The remaining lixivium, boiled again in the fame retorts with two ounces of nitrous acid until the red vapours begin to difappear, upon cooling, as before, affords 43 grains of faline aciculæ.

(F) If to the vifcid glutinous liquor which remains, there be added, at different times, fmall quantities of nitrous acid, amounting in all to two ounces; by boiling, and evaporating to drynefs, a faline mafs is at length formed, brown, glutinous, and deliquefcent, which, when perfectly dried, weighs half a drachm; but in depuration nearly half of this weight is loft.

(*a*) In order to procure this acid, common aqua fortis will ferve juft as well as the ftrongeft nitrous acid; and any glafs, thin enough to bear a moderate heat, will do juft as well as a retort. Nothing can be more eafy than the procefs for obtaining the acid of fugar. B.

X   (G) The

(G) The cryſtals obtained in the manner above deſcribed, are to be depurated by repeated ſolution and cryſtallization, an operation which is particularly neceſſary to the portion got, as deſcribed in F. The laſt lixivium F, digeſted with nitrous acid, and evaporated to dryneſs by the ſun's heat, exhibits priſms ſimilar to thoſe mentioned in D and E ; ſo that this affords a method of abridging the number of depurations.

(H) To obtain, therefore, one part of this ſalt, there are required 3 of ſugar, and 30 of nitrous acid ; ſo that it may be reckoned among the moſt expenſive ſalts hitherto known. It muſt be particularly obſerved, that a much ſmaller quantity of cryſtals will be obtained, if the boiling be continued ever ſo little beyond the proper time.

(I) The acid thus obtained I call *acid of ſugar*; not becauſe it is procurable from that ſubſtance only, but becauſe ſugar affords it more pure, and in greater quantity, than any other matter hitherto tried. Thus 100 parts of gum arabic, treated as above, with 900 of nitrous acid, at the beginning of the boiling foam violently, and upon cooling, yield ſcarce more than 21 of ſaccharine acid, priſmatically cryſtallized ; but at the ſame time the ſolution, even to the laſt, ſeparates a ſaccharated lime (§ VI), which, when collected, weighs 11, and contains about 5 of the acid of ſugar: 8 parts of highly rectified ſpirit of wine, with 24 of

7   nitrous

nitrous acid, yield 3 of faccharine acid, but
for the moft part in a fquamous form, and
loaded with much moifture; befides, honey,
and whatever fubftance contains fugar, in
the fame way produces the fame acid; and
although acid of tartar, diffolved and boiled
in nitrous acid, in the fame manner, yields
a falt fomewhat fimilar to this, both in
tafte and fquamous cryftallization, yet it is
of a whiter colour; and, befides, is un-
changeable in the fire, yielding only a coal,
as before.

In another Differtation it will be fhewn,
that the acid of fugar occurs alfo in the ani-
mal kingdom; and that it, together with a
gluten, conftitutes the calculi of the kidnies
and bladder.

§ 11. *Properties which the Acid of Sugar
poffeffes in common with other Acids.*

This falt poffeffes many properties, fome
peculiar to itfelf, fome common to it with
the other acids, though differing more or lefs
in degree: and thefe we are now to con-
fider.

(A) The cryftals have an exceeding pun-
gent tafte;—but a folution of thefe, when
fufficiently diluted, excites a very agreeable
fenfation on the tongue. Twenty grains
communicate a fenfible acidity to a kanne
of water.

(B) It

(B) It makes red all the blue vegetable juices, except that of indigo. A fingle grain, diffolved in four ounces of water, inftantly makes red the blue paper ufed for covering fugar-loaves, which is not affected by the weaker acids; and 12 grains, diffolved in a kanne of water, produce the fame effect upon paper tinged with turnfole.

(C) It attacks alkalis, earths, and fundry metals, and diffolves them with effervefcence, if they be united with aerial acid. Thefe combinations, which ferve to diftinguifh this evidently from all other acids, will be defcribed in § III.—XXIV.

(D) Diftilled water, when boiling, diffolves its own weight of the cryftals. In an heat of 15°, it diffolves only half that quantity; and, although the folution appears at firft a little turbid, it foon recovers a perfect tranfparency: the fpecific gravity of this laft folution, when faturated, is 1, 0593. The vapours which break forth during the boiling of the former folution do not contain any acid; and the liquor, as it grows gradually cold, depofits a great quantity of cryftals, many of which exhibit prifms diverging from a point. Each of thefe has four fides obliquely fituated, as in the fpar; the alternate fides narrower, of which two quadrilateral planes, generally unequal, meet together like a roof, conftituting an apex at one or both extremities. Sometimes the prifms occur fo fhort as entirely to refemble
ble

ble the fpathaceous cubes, with acute angles truncated in a parallel direction ; fo that hence we may eafily judge of their primitive form.

Sometimes the prifm is rectangular, and the planes of the apex equal : the figure of the apex too is varied by planes rifing from the angles of the prifms. If, during the depofition, the veffel be ftirred, or if the quantity of diffolved matter be infufficient, the prifms become irregular, and truncated, with five or fix fides.

(E) Thefe cryftals do not refufe to unite with other acids. Concentrated vitriolic acid, feizing the oily matter, grows brown ; and, in the end, totally confumes the cryftals, efpecially on boiling ; but when diluted, although it diffolves the cryftals readily, yet it yields them up again, but in the form of aciculæ ; a change which this acid is wont to induce alfo upon other falts. The nitrous acid greedily takes up the acid of fugar, and, upon boiling, grows yellow ; upon cooling, it again feparates cryftals, but they are generally irregular. If the folution be often repeated, with the affiftance of heat, the faccharine acid is totally deftroyed ; and at length no cryftals appear. The marine acid and vinegar diffolve thefe cryftals very completely, but they yield them again totally unchanged both as to their fhape and nature.

(F) 100 parts of spirit of wine, on boiling take up nearly 56 of this acid; but in a moderate heat not above 40. This solution grows a little turbid, and deposits a mucous sediment, scarcely equal to $\frac{1}{40}$ of the acid; on cooling, squamous crystals are formed; these are irregular, have a fragrant smell, and, on drying, grow white. In order to determine the effect of this acid in forming an ether, two drachms of the crystals, dissolved in as much spirit of wine (of the specific gravity 0, 8581) were boiled over a slow fire in a small retort; as soon as oily striæ began to arise another receiver was luted on, and half a drachm, which was contained in the former receiver, was found to be nothing but the spirit deprived of its superfluous phlegm; that which came over along with the striæ weighed only a few grains more than the former liquor, this was an acid, and, upon evaporation, yielded a crystallized saccharine acid; upon the addition of lime-water, a saccharated lime fell to the bottom, and on the top there floated a thin stratum of ether, holding, in a blue solution, a calx of copper and of gold (the last, probably, alloyed with copper). This liquor, if it may be properly called an ether, differs much from the common ether; for it is not inflammable, except when hot; nor does it burn with a white, but with a blue flame, only white on the surface; and, finally, the fragrancy of its smell is but

weak;

weak ; perhaps if the experiment was made with a larger quantity, it would fucceed better : after the ſtriæ had ceaſed, there came over a drachm of an acid liquor, which precipitated lime-water, and on evaporation yielded a cryſtalline acid of ſugar ; there came over, alſo, about half a drachm of an heavier oil : the reſiduum conſiſted of cryſtallized ſaccharine acid, and weighed 29 grains ; this reſiduum, which had but little empyreuma, again treated the ſame way with two drachms of ſpirit of wine, yielded a few oily ſtriæ, and a ſmall quantity of oil : the black reſiduum, which weighed near 12 grains, exhibited brown cryſtals ; and in the fire ſent forth a white and pungent ſmoke.

(G) Vitriolic ether diſſolves the cryſtallized acid of ſugar, but with difficulty.

(H) The ſaccharine acid unites with the oils both eſſential and expreſſed, but ſeparates again on proper evaporation : in a more violent heat, alſo, it ſeparates, by riſing above the ſurface.

(I) In an heat exceeding 15°, the cryſtals are gradually covered with a white opake cruſt ; and at length, entirely ſplitting into a white powder, loſe about $\frac{3}{10}$ of their weight ; which loſs is quickly recovered in a moiſt air: the cryſtals, when old, are covered with a looſe down, ſuch as appears upon lutes during diſtillation ; but is in no reſpect different from the ſaccharine acid itſelf.

X 4

In low clofe diftilling veffels, with a gentle fire, the water of the cryftals firft comes over (which forms about $\frac{3}{10}$ of the whole) and the acid is fufed. When the heat is intenfe, it foon liquefies, and upon boiling grows brown; a little phlegm comes over into the receiver, an acid powder efflorefces upon the luting of the receiver, and a white faline cruft fublimes, nay, when the fire is vehement, fome of it is forced over into the receiver; but the greater part is deftroyed, leaving in the retort a brown or grey matter, equal to nearly $\frac{1}{30}$ of the cryftals; this has an empyreumatic fmell, makes concentrated vitriolic acid brown, and nitrous acid yellow, but is diffolved in marine acid, without inducing any change of colour. This refiduum, expofed to the fire in an open veffel, flies off, leaving nothing in the glafs but a white fpot. The acid of fugar, when fublimed, eafily puts on a cryftalline form, and feems to have undergone no change, except that it is rendered extremely pure, being deprived of fo much of its oil as it can lofe without being itfelf deftroyed. In the receiver is found an acid liquor, which precipitates lime-water, and alfo exhibits the properties of faccharine acid, but does not eafily cryftallize: a prodigious quantity of elaftic vapour is generated, which, upon feparating the veffels, is found to be of an highly pungent and empyreumatic fmell;— this vapour, collected during diftillation,

amounts

amounts to nearly 100 cubic inches in every half ounce of the cryftals, and confifts one half of aerial acid, which may eafily be feparated by lime-water, the other half is inflammable air, and burns with a blue flame (b).

Acid of fugar which has been once fublimed, when again fubjected to the fame operation, fends forth a white fmoke, this, collected in a receiver, exhibits, upon cooling, an acid liquor, of a water-green colour, which is not cryftallizable: on the fides and neck of the retort, alfo, fome of the acid is found fublimed, and fcarcely changed; the refiduum is grey.

Upon fubliming a third time, the receiver was burft by the elaftic vapour: neverthelefs a minute portion of an acid liquor was collected, which, upon evaporating to drynefs, left a fmall refiduum: the refiduum in the retort was hoary. The changes now defcribed are brought about more fpeedily by means of heat in open veffels: the fmoke arifing is offenfive to the noftrils and the lungs, and

(b) M. Morveau obferves, that the Abbé Fontana's analyfis of this acid is confiderably different. He does not eftimate the aerial acid at above a third: and the inflammable air feemed to him to be mixed with common air. He affirms, that an ounce of the cryftals yielded 432 cubic inches of thefe elaftic fluids, a quantity nearly double to that affigned by Profeffor Bergman. M. Morveau attributes this difference to the different means which he fuppofes thefe two illuftrious philofophers employed to convert the acid into elaftic fluid. B.

the

the refiduum is of a whiter colour ; in this cafe there occur no veftiges of a coal, a circumftance which clearly diftinguifhes the acid of tartar from that of fugar.

§ III. *Saccharated vegetable Alkali.*

The acid of fugar, exactly faturated with vegetable alkali, does not yield cryftals without difficulty—but if either the acid or the alkali be a little predominant, cryftals are eafily obtained : two parts of alkali, fully aerated, combined with one of faccharine acid, being fkilfully evaporated, afford beautiful prifms, nearly of the fame form with thofe of the acid itfelf : thefe cryftals heighten the blue colour of paper tinged with turnfole ; but if boiled in the tincture of turnfole, or in fyrup of violets, they change the colour to a red : they diffolve eafily in water, but with difficulty in fpirit of wine ; they undergo fpontaneous calcination in heat : the faccharine acid is feparated from the cryftals by lime, terra ponderofa, or magnefia, when pure ; the acids of vitriol, of nitre, of falt, of fluor, of arfenic, and of phofphorus, alfo induce a change, by attracting the alkaline bafe. — Acetated and formicated vegetable alkali are decompofed by acid of fugar : but it is fire alone that can perfectly expel the faccharine acid from any bafe. In difcovering lime in any manner, lodged in waters, the faccharated

vegetable

vegetable alkali is preferable to any fub-
ftance hitherto known, as it attracts lime
moft powerfully, and is able to difengage it
from any other acid: it forms, with the lime,
a falt, very difficult of folution, which
therefore falls to the bottom in the form of
a white powder (§ vi.).   Although this ef-
fect may be produced by the acid alone, yet
the double (c) affinity accelerates the ope-
ration, at leaft never impedes it.

§ iv.   *Saccharated mineral Alkali.*

Two parts of newly cryftallized mineral
alkali, combined with one of faccharine
acid, form a falt very difficult of folution,
which is partly feparated during the opera-
tion, but what remains after evaporation
yields cryftalline grains : thefe cryftals dif-
folve perfectly in warm water, but not in
fpirit of wine; they do not change the
tincture of turnfole, but make fyrup of
violets green : the fame earths, and the fame
acids, decompofe this and the former falt ;
and, befides, the mineral alkali is expelled
by the vegetable.

§ v.   *Saccharated volatile Alkali.*

One part of faccharine acid takes up fix
of pure volatile alkali (diftilled from one of

(c) See Treatife on Elective Attractions.

fal

fal ammoniac, four of quick lime, and three
of water); this combination being flowly
evaporated, yields quadrangular prifms, ge-
nerally diverging from a number of points;
thefe cryftals not only redden tincture of
turnfole, but alfo fyrup of violets; they fplit
in heat, lofing about $\frac{1}{6}$ of their weight; this
lofs takes place in the faccharated volatile
alkali more flowly than in the acid of fugar
itfelf: water readily diffolves thefe cryftals;
fpirit of wine does not: upon diftillation,
they yield firft a concrete volatile alkali,
then fomewhat of a faccharated volatile al-
kali.—The coally refiduum indicates a de-
compofition, and confequently the difen-
gagement of aerial acid, and the caufe of the
concretion of the volatile alkali; — this
union is decompofed by fixed alkalis, and
by the earths and acids which decompofe
the former (§ III. and IV.).

§ VI. *Saccharated Lime.*

82 parts of faccharine acid take up 100
of pellucid calcareous fpar, but not im-
mediately, becaufe the furface, when fa-
turated with the acid, prevents the accefs of
the acid to the internal nucleus. Nitrated
lime is completely precipitated by acid of
fugar in the form of a white powder, not
foluble in water; of 119 parts by weight of
this powder, 72 fall to the bottom, and 47
appear upon evaporation: hence it appears,
that 100 parts contain, of acid 48, of pure
lime

lime 46, and of water 6; so that not only the presence of lime in water is discovered by acid of sugar, but even its quantity may, without difficulty, be ascertained.

The saccharine acid attracts lime with such force, that it separates it from every other: this combination, therefore, cannot be decomposed by any acid, alkali, or earth, hitherto known, and can only be decomposed by fire.

Hence, also, we understand the necessity of lime-water in the purification of sugar. For the juice of the cane contains a superabundance of acid, which prevents the dry concretion; and even if to pure sugar dissolved in water be added the saccharine acid, it will not form crystalline grains. Now nothing more powerfully attracts this acid than lime, and when united with it, it is insoluble, and either falls to the bottom, or floats in the scum; lime-water, therefore, affords the most complete means of effecting the crystallization, as it removes the impediment, and besides, may easily be added in any proportion, without communicating any heterogeneous matter. Many persons have thought that a portion of the lime remains mixed with the sugar; but if the purification be properly conducted, the nature of the ingredients, the circumstances of the operation, and finally, the most accurate analysis, abundantly shew, that there is not the smallest trace of lime remaining :—good sugar

gar diſſolves totally in diſtilled water; which could not poſſibly be the caſe if there was preſent any lime, either crude or united with the ſaccharine acid, as either of theſe ſubſtances, whether alone or mixed with ſugar, is utterly inſoluble in water. The vegetable alkali does indeed abſorb the acid of ſugar, but forms with it a ſalt not very difficult of ſolution (§ 111.), and beſides a cauſtic lixivium, if uſed in too great quantity, will diſſolve a portion of the ſugar. In ſaccharated lime the earthy baſis predominates; for, when boiled with ſyrup of violets, it ſtrikes a green colour (d).

(d) " Phyſicians are ſometimes heard to ſay, that the uſe of ſugar may be hurtful, on account of the lime uſed in refining it. But ſuch muſt belong to the claſs, unhappily too numerous, whom intereſt prompts to contend, that chymiſtry is of no ſervice in the practice of medicine.

" We have here alſo a ſtriking proof of the influence of chymiſtry in the improvement of the arts. The author's diſcovery cannot fail to illuſtrate the proceſs for refining ſugars : it had been ſuſpected that the lime attracted ſome unctuous ſubſtance, or an acid ; but this was mere conjecture, and it will be eaſy (now the object to be accompliſhed, and the manner of action of the matters employed, are known) to improve the mode of proceeding. The lime, I ſhould ſuppoſe, ſerves to ſeparate not only the ſuperabundant acid furniſhed from the cane, but that alſo which is developed by the action of fire, or by an incipient ſpontaneous fermentation of the eſſential ſalt : for, independently of the loſs in coarſe ſugars, that which has been long kept in a damp place has been obſerved to turn yellow and viſcid (gras), inſomuch that it became neceſſary to refine it again."—Morveau.

§ VII. Sac-

§ VII. *Saccharated Terra Ponderofa.*

Acid of fugar, faturated with terra pon-
derofa, quickly depofits pellucid angular
cryftals, fcarcely foluble in water; boiled
in diftilled water, they fplit, and yield an
opaque powder, but on cooling, the fmall
portion which is diffolved again concretes
into cryftals, containing a fuperabundant
acid; for this combination never cryftal-
lizes, unlefs the acid be predominant; now
the hot water takes the fuperabundant acid
from the greateft part, and therefore renders it
infoluble, no more acid remaining than what
is neceffary to faturation;—they fcarcely dif-
folve in fpirit of wine;—they yield their
menftruum to lime. Saccharated terra pon-
derofa, put into a lixivium of pure vegetable
alkali, is covered with an opaque cruft, and
at length falls into a powder: the alkali is
found united with the fuperabundant acid.

§ VIII. *Saccharated Magnefia.*

The acid of fugar diffolves magnefia, and
forms a middle falt, in the form of a white
powder, which is not foluble either in water
or fpirit of wine, unlefs the acid be fupera-
bundant. 100 parts of this falt contain 35 of
pure magnefia, and of acid and water about
65: the fluor acid is the only one which de-
compofes this falt; it is alfo decompofed by
lime

lime and terra ponderofa : pure magnefia fe-
parates the faccharine acid from alkaline
falts.

§ ix.   *Sacchárated Clay.*

42 parts of earth of alum, well wafhed,
are diffolved by digeftion in 53 of acid of fu-
gar : this folution, on evaporation, does not
produce cryftals, but a yellowifh pellucid
mafs, of a fweet yet aftringent tafte ; this
when dry deliquiates in a moift air, and
gains $\frac{2}{3}$ of its weight : it reddens tincture of
turnfole, but not fyrup of violets ; it dif-
folves fparingly in fpirit of wine ; in the
fire it fwells, the acid flies off and leaves
behind a brown earth.—100 parts contain
about 44 of earth, and 56 of acid and water.
The vitriolic, nitrous, and marine acids,
the alkaline falts, terra ponderofa, lime, and
magnefia, all decompofe faccharated clay.
Iron alfo is attacked by a folution of this
falt ; and the iron feparates, united with the
faccharine acid (§ xvi.).

Alum is not decompofed by acid of fu-
gar ; neither does nitrated or falited clay yield
their bafe to it.

§ x.   *Saccharated Gold.*

The acid of fugar does not act upon gold,
while in folution ; yet if it be precipitated
by

by a fixed alkali, and well wafhed, this acid
blackens, but fcarcely diffolves it.

§ xi. *Saccharated Platina.*

Platina is not diffolved, unlefs precipi-
tated by an alkali. Now the vegetable al-
kali partly unites with the diffolved platina,
forming a falt very difficult of folution,
which therefore, upon the addition of the
alkali, falls to the bottom like a precipitate,
although in reality it contains aqua regia,
or at leaft marine acid; therefore, to avoid
confufion, I make ufe of platina precipi-
tated by a mineral alkali, and well wafhed.
I know fome expert chymifts affert, that
this noble metal does not yield to mineral
alkali; but the contrary is eafily fhewn.—Of
this we have treated elfewhere at large,
therefore we return to the folution made by
acid of fugar; this is yellow, and yields yel-
low cryftals.

§ xii. *Saccharated Silver.*

Acid of fugar diffolves filver precipitated
by a fixed alkali but fparingly, and does
not attack the metal itfelf. This combi-
nation is moft conveniently obtained from
a faturated folution of filver in nitrous
acid: the filver, upon the addition of acid
of fugar, precipitates in the form of a white
powder, which, when wafhed, does not

change

change even the tincture of turnfole; fcarcely
diffolves in water, much lefs in fpirit of
wine; yet is foluble in nitrous acid, and
grows black by the rays of the fun. Acid
of fugar alfo decompofes vitriol of filver,
but not falited filver, fo far as I have
hitherto been able to determine with cer-
tainty.

§ XIII. *Saccharated Mercury.*

Mercury, like the former metals, is not
acted upon by acid of fugar, unlefs it be
partly deprived of its phlogifton; but in
that ftate it is diffolved, forming a powdery
white falt, which is not foluble in water,
unlefs the acid predominates, and grows
black when expofed to the fun. The fame
falt may be had from mercury diffolved in
nitrous or marine acid, by the addition of
acid of fugar, which immediately occafions
a precipitation. Corrofive fublimate, by
this method, yields a fine powder, but flow-
ly, and in very fmall quantity, which does
not grow black in the light.

§ XIV. *Saccharated Lead.*

Lead, digefted with acid of fugar, is cor-
roded, but fcarcely diffolved, unlefs it be
calcined, efpecially by precipitation with
an alkali. This folution, when approach-
ing to faturation, is made turbid by faline
grains,

grains, which feparate and fall to the bottom. The fame happens upon adding acid of fugar to folution of lead, in nitrous acid, marine acid, or vinegar : thefe cryftals contain about 55 parts of lead in 100; they do not diffolve in fpirit of wine, and fcarcely in water, unlefs it be fharpened by an acid. A folution of vitriolated lead is not precipitated by the faccharine acid.

§ xv. *Saccharated Copper.*

Acid of fugar attacks copper, even in its metallic ftate; but with greater eafe if it has been diffolved and precipitated by an alkali. Both folutions form a powder of a dilute blue colour, which, unlefs the acid predominates, is fcarcely foluble in water : 21 parts of copper require 29 of acid. Copper is precipitated by faccharine acid, from its folution in vitriolic, nitrous, or marine acid. The colour of a folution of this falt is a mixture of blue and green, the copper depofits upon zinc or iron. The acid of fugar decompofes acetated copper fo completely that the concentrated vinegar may be feparately collected, only a little adulterated with copper.

§ xvi. *Saccharated Iron.*

The acid of fugar attacks iron with an effervefcence, which is occafioned by the extrication

Y 2 trication

trication of phlogifton (*e*). The folution
has an aftringent fweetnefs; and when made
without heat exhibits prifmatic cryftals of a
greenifh yellow colour, eafily foluble in wa-
ter, poffeffing a fuperabundance of acid, and
yet fplitting in heat.   In 100 parts there
are 55 of acid, and 45 of iron.   The acid
being expelled by fire, there remains a ferru-
ginous mafs marked with greenifh fquamu-
læ on the furface, but the nucleus verges to
a brown.

Calx of iron is alfo diffolved; but on di-
gefting both it and the foregoing folution,
they yield nothing but a yellow powder, fuch
as is precipitated from green vitriol by acid
of fugar, and is alfo had in the preparation
of the faccharine acid, when the nitrous
acid employed abounds with iron.   This
powder is almoft infoluble in water, but on
boiling feparates an ochre.

(*e*) " I do not believe that the feparation alone of phlo-
gifton can occafion a fenfible effervefcence : this phæno-
menon takes place in the folution of metals, in proportion
to the decompofition of the acid, at leaft a partial decom-
pofition ; whence an elaftic.fluid is produced, which unites
with phlogifton, and becomes inflammable air." Morveau.
—Mr. Kirwan would explain this appearance by faying,
that the acid, in diffolving the metal, gives out fire to
the phlogifton, which enables it to affume an aerial form ;
and if it fhould at laft be proved that inflammable air is
one of the ftates of phlogifton, this muft be accepted as the
true theory.   B.

§ xvii. *Saccharated Tin.*

Tin, by the affiftance of heat, is blackened by the acid of fugar, and at length covered by an hoary powder: the folution emits elaftic vapours, poffeffes an auftere tafte, and exhibits prifmatic cryftals; but when quickly evaporated to drynefs, nothing remains but a corneous mafs, which being diffolved, on the addition of an alkali yields a copious precipitate. The calx of tin is alfo eafily diffolved, and both the combinations make tincture of turnfole red.

§ xviii. *Saccharated Bifmuth.*

The regulus of bifmuth is fomewhat corroded by acid of fugar; but the calx only is diffolved.—This falt is powdery and white, and fcarce foluble in water: the metal conftitutes one half of its weight. If to a folution of nitrated bifmuth be added the faccharine acid, in the fpace of an hour polygonal tranfparent grains concrete at the bottom of the veffel, which have the fame properties as the above-mentioned powder, nor do they occafion opacity in water, like the cryftals of nitrated bifmuth.

§ xix. *Saccharated Nickel.*

The regulus of nickel, digefted in acid of fugar, is covered with a greenifh white cruft, and at length all fplits into a powder of the

fame

fame colour; the green calx alfo affumes
the fame colour, even without heat.—This
combination contains twice as much acid as
metal. The faccharine acid precipitates a
powder of the fame kind from nickel dif-
folved in vitriolic, nitrous, or marine acids :
this falt is diffolved in water in fmall quan-
tity, and affumes a yellow colour, fcarce
tinged with green; and the cryftals are of
the fame colour.

§ xx. *Saccharated Arfenic.*

Arfenic in a reguline ftate is fcarcely dif-
folved by digeftion, but white arfenic is
eafily taken up without heat; on evapora-
tion it exhibits prifmatic cryftals, which,
melting with a gentle heat, emit the fuper-
abundant acid, and fhoot into elegant rami-
fications; thefe eafily diffolve in water, and
in fpirit of wine make tincture of turnfole
red; are fublimed by a gentle fire, but de-
ftroyed by a ftronger; the faccharine acid
firft flying off, and then the white arfenic,
with a fmell of garlick.

§ xxi. *Saccharated Cobalt.*

Acid of fugar attacks cobalt, either with
or without heat, and converts it into a pow-
der of a dilute rofe-colour. The folution is
more yellow, and exhibits cryftals of the
like colour, abounding in acid, and there-
fore eafily foluble; but the rofe-coloured

powder,

powder, which does not change turnſole, is ſcarcely ſoluble in water.   The acid of ſugar, in a moderate heat, takes up more than an equal weight of precipitated cobalt : on the addition of common ſalt this ſolution yields a ſympathetic ink.

The ſaccharine acid ſeparates cobalt from all acids yet known, and forms the above-mentioned powder.

§ XXII. *Saccharated Zinc.*

Regulus of zinc effervefces violently with ſaccharine acid, and is ſoon covered with a white powder: this, in 100, contains 75 of metal, and is not ſoluble in water, unleſs when the acid predominates : the calx yields a ſimilar powder, and on the addition of acid of ſugar to ſolutions of zinc, in vitriolic, nitrous, or marine acids, a ſimilar powder is obtained.

§ XXIII. *Saccharated Antimony.*

Regulus of antimony grows black in digeſtion with ſaccharine acid, but the calx and the glaſs are diſſolved, though ſlowly.—— The ſolution, in which the acid is always predominant, exhibits cryſtalline grains, which are ſcarcely ſoluble in water.   The acid of ſugar precipitates ſimilar grains from acetated glaſs of antimony, but not

Y 4   from

from the butter ; yet it takes antimony from the vitriolic acid.

§ xxiv. *Saccharated Manganese.*

Magnesia nigra effervesces with acid of sugar, even without heat ; but the saturated solution deposits a white powder scarcely soluble in water, unless the acid be super-abundant. This salt grows black in the fire, but again, upon the affusion of acid, is turned to a milky powder, such as is precipitated (mixed with some crystalline grains) upon the addition of saccharine acid, from the solutions of manganese in vitriolic, ni-trous, or marine acids.

§ xxv. *Elective Attractions of Acid of Sugar.*

From the preceding experiments it ap-pears, that the elective attractions of acid of sugar are as follow, *viz.* Lime claims the first place (§ vi.) ; terra ponderosa the second (vii) ; then magnesia (viii.) ; vege-table alkali (iii.) ; mineral alkali (iv.) ; volatile alkali (v.) ; and lastly, clay (ix.). With regard to other acids, the saccharine acid yields alkalis to vitriolic, nitrous, and marine acids, arsenical acid, acid of fluor, and phosphoric acids (iii.) ; it yields lime to none (vi.) ; terra ponderosa, to vitriolic

acid

acid (VII.) ; magnefia, to the fluor acid
(VIII.) ; clay, to vitriolic, nitrous, and ma-
rine acids (IX.) ; filver (XII.) and antimony
(XXIII.) to marine acid ; lead (XIV.) and
perhaps tin (XVII.) to the vitriolic ; but
mercury (XIII.), copper (XV.), iron (XVI.),
bifmuth (XVIII.), nickel (XIX.), cobalt
(XXI.), zinc (XXII.), and manganefe
(XXIV.), to none, fo far as is yet known. As
to the metals, though they are fet down by
all in the table of fimple elective attractions,
their forces being determined by precipita-
tion ; yet, properly fpeaking, they do not
belong to that place, as thefe precipitations
are in fact performed by means of a double
elective attraction.—If, however, any one
wifhes to keep them in that place, he may
take it for granted that they preferve nearly
the fame order, whatever menftruum they
are diffolved in.

§ XXVI. *Whether faccharine Acid owes its
Origin to the nitrous.*

Hitherto we have confidered the proper-
ties of acid of fugar ; it now remains to fay
fomething of its origin : and here a quef-
tion firft occurs, whether it be truly and
perfectly inherent in the fugar, or whether
it be generated during the boiling, by the
adventitious nitrous acid ? I do not deny
but that, at firft fight, the nitrous acid ap-
pears

pears to contribute fomething to the gene-
ration of this acid, as all attempts to gene-
rate it without the affiftance of that acid
have hitherto failed.   I once thought, that
the nitrous acid, being very greedy of phlo-
gifton, is by that means able, during the
procefs, to fpoil the faponaceous mafs of
fugar fo far of its inflammable principle
that it can at length give out its faline prin-
ciple alone ; yet I never could accomplifh
this end, either by diftillation of fugar, or
detonation with nitre ; by digeftion or de-
coction with vitriolic or dephlogifticated
marine acid; nor finally by manganefe :
however, although the experiments hither-
to tried have proved fruitlefs, we are not
authorized to conclude that there is no pof-
fible means of extracting the acid of fugar
without the help of nitrous acid ; at leaft,
it cannot be proved by any probable, much
lefs conclufive argument, that nitrous acid
enters into the compofition of the acid of
fugar.—Sugar is either fpontaneoufly or ar-
tificially feparated from certain vegetable
juices, and is therefore confidered as an ef-
fential falt : now all fuch falts, as we know,
poffefs acids peculiar to themfelves ; it will
therefore hardly be denied that the fame is
the cafe with refpect to fugar, though we were
ignorant of any other proofs.   In common
fugar, the fuperabundant acid is carried off
in fuch a manner during the preparation, as
to efcape the notice of our fenfes : never-

<div align="right">thelefs</div>

thelefs thofe converfant in chymiftry can entertain no doubt concerning that which remains (*f*).

We conclude then that an acid does exift in fugar : it remains to enquire, whether this be altered by the nitrous acid.

If we examine the operation with all due attention, we fhall find that nitrous acid has fuffered no other change than the following : it grows red, being loaded with phlogifton, it becomes more volatile and more weak, and a part of it affumes the nature and properties of that elaftic fluid now diftinguifhed by the name of nitrous air : again, nothing more is required than that the effential acid entangled in the oily part be fet at liberty, and this is obtained in an highly active ftate (§ 1. G), although ftill loaded with fo great a quantity of phlogifton as to exhibit cryftals, while other acids, being deprived of that principle, are always fluid; and this folid ftate is competent to faccharine acid, even when further deprived of phlogifton (§ III. I.) (*g*).

If we confider the nature of the acid of fugar,

(*f*) The acid of refined fugar is developed fo as to make a fenfible impreffion on the teeth. Morveau.

(*g*) If it be in general true, that the concrete ftate of the acids is owing to phlogifton alone, neither the fedative nor the phofphoric acid, in a glafly ftate, nor that of arfenic, can be free from it ; yet the two laft form with it folid fulphur, as well as the vitriolic ; and the folidity is

probably

fugar, we fhall find that it does not refemble
the nitrous acid in any other inftance than
thofe properties which are common to all
acids : befides, it expels the nitrous acid
from lime, terra ponderofa, magnefia, and
metals (§ xxv.) ; yielding to the other acids
nothing but alkalis (§ 111.) While the ni-
trous acid produces falts, either deliquefcent
or eafily foluble, acid of fugar yields fuch as
are fcarcely foluble in water (§ vi. viii. xii.
xv. xvi. xix. xxi.) Alkalis, when nitrated,

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probably owing to the fame combination.   On the other
hand, a fluid form is effential to marine acid not dephlo-
gifticated ; vinegar, though loaded with unctuous mat-
ter, cannot be obtained concrete ; nitrous acid is chang-
ed by phlogifton into gas, and the volatile vitriolic acid
preferves its fluidity.   It appears, indeed, that thefe laft-
mentioned combinations are modified by air, which caufes
the difference between fulphur and the fulphureous acid ;—
but thefe obfervations ought not the lefs to guard us againft
generalizing the principle.   The analogy obferved by the
author may be very juft, when confidered with refpect to
fome particular phænomena; and it is very poffible that
the fluid vitriolic acid may harbour as much phlogifton as
cryftals of the faccharine acid before calcination : the
more or lefs deftructibility of a compound does not al-
ways indicate the proportion of the conftituent parts :
laftly, the fluidity of acid is a real ftate of fufion, like that
of mercury ; this idea, which I had not confidered (l. c.)
but with refpect to its connection with the general fyftem
of the properties of bodies, is confirmed by the fine expe-
riments of the Duke d'Ayen, on the congelation of the vi-
triolic acid in a temperature 15 degrees below the freez-
ing point [2° or 3° below 0 of Fahrenheit's fcale.]

Morveau.

detonate

detonate with ignited phlogifton, but when
faccharated, fhew not the leaft figns of defla-
gration, which they evidently do upon the
addition of the fmalleft particle of nitrous
acid. The nitrous acid corrodes tin and
antimony, but fcarcely diffolves them, while
acid of fugar readily acts upon them : phlo-
gifticated nitrous acid, united with vegetable
fixed alkali, deliquefces, does not form cryf-
tals, and is readily expelled by vinegar, or
even by acid of fugar ftill more loaded with
phlogifton : all which circumftances by no
means take place with refpect to the fixed
vegetable alkali united with acid of fugar.
Many other diffimilarities will occur upon
comparifon, fo that thefe acids are of a nature
not only unlike, but in many inftances dia-
metrically oppofite. If any will attribute
all the difference to phlogifton, I will not
deny, that that fubtile principle forms a
wonderful fource of difference ; but the dif-
ferences which take place here can by no
means be attributed to this when properly
examined. The nitrous acid is weakened,
and made far more volatile, by union with
the phlogifton ; the acid of fugar much more
fixed, even when loaded with fo great a
quantity as to be cryftallizable ; — it almoft
every where expels the ftrongeft nitrous
acid, as experiments fhew ; befides, the phlo-
gifticated nitrous acid produces, with the
very fame matters, compounds totally dif-
<div align="right">ferent</div>

ferent from thofe with acid of fugar.   No-
thing can be judged from circumftances
which are unknown, forged, or at beft pof-
fible—and among all the facts yet known
concerning the acid of fugar, we can find no
figns of its being derived from the nitrous
acid.

However, let us enquire more deeply;
let us principally confult nature, not in-
differently and flightly, fupplying the de-
ficiencies with fiction, but candidly and
properly, by apt and accurate experiments,
otherwife her anfwers, like thofe of the
oracles of old, will be either delufive or
ambiguous.

But, by whatever means the acid of fugar
is produced, it muft be confidered as dif-
tinct and different from all others, be-
ing always effentially and fpecifically the
fame.   Its fingular properties, fome of
which are of confiderable ufe in chymif-
try, fhew that it deferves the moft particu-
lar attention : from the time of Stahl, many
confidered the nitrous and marine acids as
generated from the vitriolic ; but if all con-
fiding in this theory (which yet is contra-
dicted by daily obfervation) had neglected
the examination of thofe acids, confidering
them as fubordinate and derivative, we fhould
be to this day ignorant of many fingular
facts, which by degrees were difcovered,
principally becaufe many confidered thefe

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acids

acids as diftinct and feparate fubftan-
ces, (*h*).

(*h*) To the hiftory of the Acid of Sugar, accident, and
the enquiries of later chymifts, enable me to make addi-
tion.—Profeffor Murray, of Gottingen, has affirmed, that
Mr. Schrikel has obtained it by repeated diftillations and
congelation, without ufing any nitrous acid. M. Mor-
veau, from whom I learn this, adds nothing further con-
cerning the procefs. Was it in this cafe procured by dif-
tilling fugar with the black calx of manganefe, or the calx
of lead, fubftances which attract the inflammable principle
with confiderable force ? yet the author failed, as he did
alfo in attempting to dephlogifticate the faccharine acid
by means of the dephlogifticated muriatic acid. The expe-
riments, however, mentioned by Profeffor Murray fur-
nifh an irrefragable argument of the effential difference
between the nitrous acid and that of fugar. Though
the author's reafoning, by every unprejudiced perfon, will
be thought to prove this abundantly, there are fome chy-
mifts of note, and teachers of chymiftry, who maintain,
that the faccharine acid is nothing but nitrous fulphur.
" The Abbé Fontana has obtained an acid perfectly
like that of fugar, and faccharine fubftances, from all the
gums and refins." (Journ. Phyf. tom. xii. p. 182, and
tom. xiii. p. 23.) Morveau.
I have heard that it has been procured from oils ; but the
moft interefting difcovery of this fort was made by the ce-
lebrated Mr. Watt of Birmingham :—he was, I under-
ftand, making fome experiments relative to ink, when he
obferved a number of bodies floating in the fluid, which
had the fhape of cryftals of the faccharine acid, and upon
examination were found to be really fuch : he found, by
adding nitrous acid to galls, and conducting the procefs in
the way recommended by Profeffor Bergman, that thefe
aftringent bodies contain the acid of fugar in greater
abundance than the fubftance from which it derives its
name.—I cannot be certain that thefe circumftances took
place exactly as I defcribe them, but I have reafon to fup-
pofe that this account is near the truth. B.

DISSERTATION IX.

PREPARATION of ALUM.

——————

§ 1. *Various Uses of Alum.*

NATURE produces but a very small
quantity of native alum ; and this is
mixed with heterogeneous matters, or efflo-
refces in various forms upon ores during
calcination ; but rarely occurs cryſtallized.
In this latter ſtate it is reported to be found
in Egypt, Sardinia, Spain, Bohemia, and
other places ; I have ſometimes ſeen it
generated in the aluminous ſchiſt of Lap-
land and Weſt Gothland, by a ſpontaneous
decompoſition of the ore ; beſides, it is
found diſſolved in the aerial waters : it is
found, but very rarely, in fountains, and in
hot medicated waters.——After having con-
ſidered the various uſes of this ſalt, we ſhall

examine

examine at what time it firft began to be artificially prepared.

In the difpenfatories alum enters many preparations, liquors, collyria, gargles, plaifters, bolufes, pills, powders, and others : by its mild acidity it coagulates milk ; and it, befides, poffeffes a remarkable aftringent power.

In the arts, alfo, and the œconomy of private life, the ufe of this falt is very frequent ; it is added to tallow to make candles hard. The printers cufhions are rubbed with burnt alum that the ink may ftick ; and for the fame reafon the inftruments ufed for printing linen. Wood fufficiently foaked in alum does not eafily take fire : the fame is true of paper impregnated with it ; which, for that reafon, is very proper to keep gun-powder, as it alfo excludes the moifture of the air. Paper impregnated with alum is ufeful in whitening filver and filvering brafs without heat ; it is ufeful, added to milk, which does not eafily feparate its butter ; in the conglutinating of feveral fubftances ; in making the pyrophorus ; in tanning ; and many other manufactures.

In the art of dying it is particularly ufeful, in the preparation of the matters to be dyed ; for by cleanfing and opening the pores upon the furface by a gentle corrofion, it both renders the fubftance fit for receiving the colouring particles (by which

Z

the

the alum is generally decompofed) and at the fame time makes the colour fixed.

It conftitutes the bafis of crayons, which generally confift of the earth of alum, finely powdered and tinged for the purpofe. This it is which, in the preparation of Pruſſian blue, prevents the bafis of the martial vitriol, which is foluble in acids, from being precipitated by the fuperfluous alkali ; that is, the alkali not faturated with the colouring matter. As this bafis adheres more ftrongly to the vitriolic acid than the clay does ; and as, by the mixture of its yellownefs, it would form a green, the very white earth of alum, alfo, according to its quantity, dilutes the darker colours, even black itfelf, and produces infinite degrees of intenfity. It is unneceffary to fay more of its ufeful qualities.

§ 11. *Brief Hiſtory of the Preparation of Alum.*

The στυπτηρια of the Greek, and the *alumen* of the Romans, was a native fubftance, and differed much from the falt which now goes by thofe names. The varieties of alum mentioned by Diofcorides refer to ftalactites, which contained very little, if any, alum ; and that completely enveloped by a vitriolic matter. The defcriptions of Pliny are ftill more difficult to be underftood, as he had not feen the fubftances, the defcription of

which

which he undertakes, but merely tranfcribed from the writings of others.

The factitious falt, which is now called alum, was firft difcovered in the eaftern countries ; but when, where, and by what means, is unknown. On account of its fimilarity in aftringency, and its ufe in the arts of tanning and dying, the new falt has retained the old name, which was afterwards called mify. fory. calcanthum, or fhoe-maker's black.

Among the moft early works eftablifhed for the preparation of alum, we may juftly number that of Roccho, a city of Syria, now called Edeffa ; — hence the appellation of Roch alum, a name which is generally fo ill underftood, that many to this day imagine that it is the fame as rock-alum. In the neighbourhood of Conftantinople there were many alum works, as alfo at Phocæa Nova, now called Foya Nova, not far diftant from Smyrna. The Italians hired and made ufe of many of thefe ; but about the middle of the 15th century, they introduced the art into their own country, and that with the greater earneftnefs, as the ufe of the falt became more frequent, and occafioned the drawing large fums of money out of the country.

Bartholomew Perdix, or Pernix, a merchant of Genoa, who had often been at Rocha, difcovered the matrix of alum in the ifland of Ifchia, about the year 1459, and

Z 2   eftablifhed

eftablifhed a manufactory there ; at the fame time John de Caftro, who had vifited the manufactories at Conftantinople, difcovered a matrix at Tolfa, by means of the ilex aquifolium, which he had alfo obferved to grow in the adjacent mountains of Turkey ; and his opinion was confirmed by the tafte of the ftones. The attempts made by the Genoefe at Viterbium and at Volaterre, fucceeded extremely well : the preparation of it in Italy foon encreafed wonderfully faft ; and the induftry of the natives was much ftimulated by an edict of Pope Pius II. prohibiting the ufe of oriental alum, and appropriating the revenue arifing from that made in Italy to carrying on the war againft the Turks.

But the art was not confined to Italy : in the 16th century a manufactory was eftablifhed at Alcmaron in Spain, in the neighbourhood of Carthagena, which ftill fubfifts.

There were many manufactories in Germany in 1544, of which that at Schwemfel in Mifnia ftill remains. Long fince, in the time of Agricola, alum was boiled at Commotau in Bohemia.

The firft manufactory in England was eftablifhed in the reign of Elizabeth, at Gifborough, by one Thomas Chaloner.

The art of preparing alum made its way into Sweden very late ; and although we have now no lefs than feven manufactories,

not

not one of them was founded before the 17th century.

The moſt ancient, eſtabliſhed in Scania at Andrarus in 1637, had twenty-two ſingle, or twelve double boilers. (We ſhall ſee hereafter what is meant by double and ſingle boilers). In this place the ſtratum of alu-minous ſchiſt is very deep, being upwards of 360 feet; but all the boilers are not uſed every year. In the year 1765, 2,735 ton of alum were manufactured; in 1766, 3,099; in 1767, 2,423; and in 1768, 1,427.—A ton of alum weighs 344 lb.

At Lofver, near Calmaria, in Smoland, another manufactory was built in the year 1721; there were employed in this, beſides one boiler for purification, only four double boilers, although the patent allowed five; much inconvenience being occaſioned by bringing the mineral from Ocland, and by the ſcarcity of wood. In 1765, there were made 1,020 ton; in 1766, 926; and in 1767, 800;—the average for ten years was 1,000 ton.

In Weſt Gothland there are four; the firſt at Mulltorp, near the town of Schæfde; this has only two ſingle boilers, and the ore is in the neighbourhood. In 1765 there were made 90 ton; in 1766 no more than 71.

At about half a mile's diſtance from Ol-torp, in the diſtrict of Dimbo, a patent was granted in 1726, for three ſingle boilers;

in

in 1765 were made 157 ton; in 1766 300.

A third at Kafvelas obtained, in 1748, a patent for two single boilers; to which, in 1765, were added two more;—the ore is diftant a quarter of a mile. This produced, in 1765, 312 ton; and in 1766, 293.

A fourth at Hænfæter in Kinekulle, obtained a right of two single boilers in 1766;— the ore is found in the neighbourhood.

The greateft manufactory was eftablifhed at Garphyttan, in Nericia, in the year 1766, with a privilege of ten single boilers, which was encreafed to thirty in 1769. Here, while the matrix is burned, the boiling is performed by means of a peculiar conftruction of the furnaces; and whether we confider this manufactory with refpect to the greatnefs of the works, the convenience of the apparatus, or the goodnefs of the. alum (which even excels the Roman) we muft acknowledge that it is beyond comparifon fuperior to them all.

The diftrict of Ljung, in Oftro Gothland, has had for many years a privilege of boiling alum; but the work has not yet been fet on foot.

Every thirtieth ton goes to the royal revenue.

A fingle boiler is $5\frac{1}{2}$ feet in breadth, 11 in length, and in depth at the front 3, at the rear $2\frac{1}{2}$, and contains 1,663 kannes, and 6 quadrants. The double boiler is of the fame depth

depth and length, but is ten feet broad, and contains 3,025 kannes.

§ III. *Proximate Principles of pure Alum.*

(A) Alum is an imperfect middle falt, confifting of vitriolic acid and pure clay; it takes up a confiderable quantity of water in cryftallization; and, if the procefs be not interrupted, yields octaedral cryftals, which are tranfparent, and colourlefs as water.

(B) The acid is a little fuperabundant, fo as to redden the tincture, and even the paper of turnfole. This excefs of the acid is effential; for, upon taking it away, all the tafte, all the folubility, and all the original properties of the falt, are loft (*a*).

<div align="right">The</div>

(*a*) M. Morveau will not admit a fuperabundance of acid in alum : he thinks it would be neceffarily feparated by edulcoration and cryftallization, when it is no longer held by its affinity with the earthy bafe, or the falt itfelf, when it is formed.   He thinks, that the change of blue vegetable juices to red is not an unequivocal proof of the prefence of an uncombined acid, an opinion which Mr. Kirwan has alfo adopted.   In the prefent cafe it fhould be remembered, that we have certain proof that a portion of vitriolic acid adheres to the clay lefs tenacioufly than the remainder.   If a piece of iron be put into a folution of this earthy falt, it will attract this portion of acid, and the vitriolated clay will fall down infoluble.   Now we may prefume, that this loofely adhering acid produces the change on blue vegetable juices;—the fame thing is true of phofphorated calcareous earth. A folution of this falt will yield the fuperabundant acid to a bafe which attracts

<div align="right">it</div>

The proportion of the principles is afcertained in the following manner :—the water is expelled by a gentle heat ; the remaining mafs grows opake, fwells, foams, and at length remains quiet, fpongy, and friable. The quantity of earthy bafis may be determined by precipitation with fixed or volatile alkali. In this way, 100 parts of cryftallized alum are found to contain 38 of vitriolic acid, 18 of clay, and 44 of water : let it be obferved, however, that the earthy precipitate is not totally deprived of its acid ; for when the alkali is added, the fuperabundant acid is firft taken up, and thus a great part precipitates, its acid being diminifhed, but not quite abftracted ; and hence the precipitate, by the affiftance of fire, partly decompofes feveral falts ; and long continued digeftion in an alkaline lixivium, is neceffary to feparate all the acid.

(c) Chymifts have differed in opinion concerning the nature and proper name of the earth of alum. Meffrs. Geoffroy and Hellot firft extracted it from common clay ; Dr. Pott did the fame, but feems to confider it rather as a production than a feparation : at length the celebrated Margraaf, by experiments which deferve well to be

it with far lefs power, and then the middle falt will be precipitated infoluble ; fo that, in both thefe cafes, a quantity of acid above that which is required to attain the precife point of faturation, is neceffary to folution and cryftallization.   B.

attended

attended to, demonftrated that all clay upon the furface of the earth confifted invariably of two principles mechanically mixed, one of which forms the genuine earth of alum, which is perfectly different from cal-careous, gypfeous, or metallic earths, and from magnefia. I am not certain whether this may be derived from the calcareous earth : to determine this point I have made a great number of experiments of different forts, but have not thence been able even to form a conjecture. Vague fimilitudes in certain properties are never fufficient to determine a perfon who earneftly feeks for truth, and is not fhackled by hypothefis. —Since then the earth of alum is found to poffefs different properties from other earths, it ought to be diftinguifhed from them ; and, fuppofing it in reality derived from the calcareous or any other known earth, yet it requires the addition or abftraction of fome other principle ; for the bare change of magnitude or figure in the particles will never account for fo great a difference ; and therefore the primitive and derivative earths (fuppofing them to be fo) muft be confidered as diftinct and feparate.

Befides, as an equal quantity of the earth of alum may be extracted from a given common clay, by means of different acids, it muft be only mixed with thefe clays ; for if it was generated by the menftrua during the operation, it would no doubt vary both in
quantity

quantity and quality, according to the dif-
ferences of the menftrua : but the moft ac-
curate experiments prove the contrary, as they
always procure the earth of alum the fame
in quantity and quality, and the very fame
refiduum ; and fynthefis, in this cafe, pro-
duces full conviction : for if the earth of
alum, and a due proportion of filiceous earth
finely powdered, be added together, they re-
generate common clay.

It may be afked, why the bafe of alum is
confidered as a pure clay ? — the anfwer is,
that earth which is called clay is chiefly
diftinguifhed by its tenacious and plaftic
quality when moiftened, by its cracking
when dried, and finally by its acquiring a
flintly hardnefs in the fire : now as thefe
fpecific properties do not depend upon the
filiceous particles (which are not capable of
being either foftened or hardened) but folely
upon the earth of alum, it appears moft
evident that the filiceous particles might be
abfent, and the argillaceous nature remain ;
and that therefore the refiduum is that
which conftitutes the argillaceous nature.
Pure clay, it is true, may occur in the bow-
els of the earth, but very rarely free from all
filiceous particles ; and the variety in the
proportion of this latter fhew plainly that
its prefence is only accidental : for the pure
clay is very fubtilely divided, and very rea-
dily mixes with and adheres to heteroge-
neous matters, as will readily appear upon
examination ;

examination; yet it is remarkable for the intensity of its properties. Thus common clay often contains $\frac{1}{2}$ or even $\frac{3}{4}$ and upwards, of filiceous matter; yet the fmall portion of pure clay which is prefent is able to imprefs its own character, and communicate its own qualities, to the whole mafs fo completely that no one can doubt of its argillaceous nature. By common confent, that earth which by mechanical wafhing, without the addition of an acid, depofits upwards of 70 lb. in 100 of filiceous matter, is called clay; now it is evident that this foreign fubftance, by the largenefs of its quantity, muft temper the qualities of the pure clay. The argillaceous earth contracts by heat very much, even to half, its bulk; hence, if it be ufed for cieling or plaiftering it neceffarily cracks and feparates from the walls, when a fufficient degree of heat takes place, nor can it adhere to them, unlefs when fufed, an operation which pure clay cannot be made to undergo, even in the focus of a concave mirror; but the addition of filiceous earth reftrains the propenfity to contraction in the whole mafs, fo that it remains of due dimenfion; and this property is well known to builders, who conftantly avail themfelves of it (b). He who attempts to make well depurated

(b) "Clay fo much burned as to ftrike fire produces the fame effect as flint; which proves either that flint ferves
like

purated earth of alum fufible, by mixing it with common clay, either confounds the clays with others, containing not a particle of clay, or has never made the experiment. —The fame is true of other pretended qualities :—alum fwells, pure clay does not— the earth of alum, deprived of all its acid, and the precipitating alkali adhering to it, does not fufe with calcareous earth, without the addition of a flinty matter, as the celebrated Macquer has fhewn : but we muft take care that the calcareous earth contains no flinty matter, which fometimes happens ; for in this cafe the experiment will fail, becaufe the fmalleft particle of flint communicates a degree of fufibility to the two ingredients.

(D) 100 parts of cryftallized alum requires, in a mean heat, 1,412 of diftilled water to diffolve them, but of boiling water only 75; fo that a kanne of water, in a moderate heat, takes up 2,992 grains of alum, and by a boiling heat 56,333.— This folution has a fweetifh aftringent tafte.

like any other matter not capable of contracting ; or that, by burning, clay approaches the nature of flint : it certainly undergoes a confiderable change in the fire, as it lofes the property of being diffufible in water. Such facts, known only by means of manufactures, afford very little infight into nature, till chymiftry has examined them carefully." Morveau.—That clay does not change its nature by being burned appears evidently from an experiment with which M. de Morveau was feemingly unacquainted : — if hardened clay, fuch as cannot be treated with water, be diffolved in vitriolic acid, and then precipitated, it regains its former properties, and may be diluted by water. B.

The

The specific gravity of alum, computed from the increase of bulk, or of distilled water into which it is put, is 2,071, if the air-bubbles produced during the solution be removed; but if they are taken into the computation, 1,757. This air is not taken away by the air-pump, but if heat be applied during the solution, it flies off, and upon examination is found to contain nothing but aerial acid.

§ iv. *Aluminous Ores.*

The ores from which alum is artificially prepared are of two kinds, the one contains the alum already formed, the other its proximate principles, which unite on roasting. These must be considered separately; —and we shall first examine the latter species, as being best known and most frequently met with.

(a) The aluminous schist is nothing more than an argillaceous schist impregnated with a dried petroleum, and thereby rendered black. The oil is easily extracted by distillation: if, by means of menstrua, we analyse it entirely, many ingredients appear; namely, an argillaceous martial substance, often amounting to $\frac{3}{4}$; a siliceous, forming $\frac{1}{6}$; and generally also a small portion of calcareous earth and magnesia; the rest is all pyritous.

During

During the roasting, the bituminous part is expelled, and the pyritous decompofed, fo that a part of the acid adheres to the iron, and the reft to the pure clay ; hence are produced at once alum and green vitriol, and if there be prefent any calcareous earth, or magnefia, they are vitriolated.

Nothing faline is extracted by water from the fchift before the roafting, though it be well powdered, nor can the tafte difcover any veftiges of a faline matter ; hence alfo it appears to be generated during the operation, and for that purpofe nothing feems to be neceffary but the prefence of a pyrites ; this fometimes fhews vifible nuclei of different fizes, but is generally difperfed through the whole mafs, in the form of very minute particles : the goodnefs therefore of the ore, is to be eftimated by the fuitable quantity and equal diftribution of the pyrites.

That which contains the pyrites fo copioufly that it is vifible, is rejected, there being too much iron in it—in the mean time the moft denfe and ponderous is moft efteemed ; the weight manifeftly difcovering a pyrites, without which no alum is obtained. In this point there generally occurs a confiderable difference, which arifes doubtlefs from the unequal diftribution of the pyrites : hence a ftratum adjoining to one of the beft kind, is often of little or no value. The ore which produces lefs than 4 lb. in 100 does

does not, with us, pay the expence of the procefs.

Sometimes this ore produces falts without the application of fire; but we muft obferve, that in this cafe it is never found, but has undergone more or lefs of a fpontaneous calcination.

A fmall piece expofed to fire upon a coal with a blow-pipe, often decrepitates, but when once made thoroughly hot it fmokes, with a bituminous fmell, and eafily melts; —with mineral alkali it effervefces violently, and is divided, but not entirely diffolved: it is taken up (though flowly) by the microcofmic falt; but more quickly by borax: thefe phænomena are eafily explained from its compofition.

This ore is fometimes found naturally divided, and heaped together, under the forms of grains or a coarfe powder; but it agrees with the former in nature and properties.

(B) The other fpecies of ore, which not only contains the proximate principles, but contains them united, is only found in volcanic countries: fuch is that which is employed at Tolfa, near Cincelles, for boiling that fpecies of alum which is called Roman alum;—it is probable that this had been long hardened by the fubterraneous fire, and penetrated and whitened by the vapour of the phlogifticated vitriolic acid (c):

(c) De Productio Ignis fubterranei.

3   a ftony

a ftony mafs, with veins of quartz, and ex=
tremely hard, is alfo found in that country;
that which is void of flavour very rarely
produces alum upon elixation.

It fometimes, though rarely, contains
calcareous particles. I have feveral pieces,
weighing in the whole at leaft half a
pound, in which there is not the flighteft
trace of any thing calcareous ;—upon burn-
ing it does not exhibit the leaft refemblance
to lime, for it neither generates heat with
water, nor falls into a powder, but only
cracks fo much as to affift the efflorefcence
and elixation.

When examined by the blow-pipe, it does
not flow of itfelf; with the mineral alkali,
at firft it fhews a momentary effervefcence,
but is not divided, much lefs diffolved;
with borax and microcofmic falt it effer-
vefces, and is at length all taken up, exactly
in the fame manner as burned alum. Thefe
phænomena abundantly fhew that the alum
is ready formed, but inveloped in a large
quantity of clay. This mineral, therefore,
reduced to a fubtile powder, and treated in the
ufual way with vitriolic acid, is almoft all
converted into alum, which could not be the
cafe with calcareous earth.—I found that
the fmall portion which remains is more
frequently filiceous than gypfeous (d).

At

(d) " According to Mr. Monnet, it does not contain
alum perfectly formed : but if a combination of nearly equal
parts

At Solfatara, near Naples, the old lava is at prefent whitened by the phlogifticated vi-triolic acid, the clay is changed into alum, the mafs efflorefces, and is refolved into a white earth, from which a faline matter is extracted by water. I examined 100 of the white earth, and found in it 8 lb of perfect alum, befides 4 of pure clay, and the refidue was filiceous : but this proportion muft be va-riable, as rain diffolves and carries off the falt; fo that the proportion of filiceous mat-ter continually encreafes, and perhaps in fome parts the alum is entirely wafhed away.

(c) There are found alfo other varieties of aluminous ores. In Haffia and Bohemia this falt is obtained from wood impregnated with bitumen. At Helfingborg, in Scania, a turf is found, confifting of the roots of ve-getables, mixed with nuts, ftraw, and leaves, often covered with a thin pyritous cuticle, which, when elixated, yields alum; nay, the fulphureous pyrites is generally mixed with an argillaceous matter, which may be fepa-rated by menftrua. To that at Dylta, in Nericia, when fulphur is firft obtained by diftillation from the pyrites, and afterwards from the refiduum expofed to the air, till it efflorefces, a green vitriol is elixated; at length from the magiftral lixivium alum

parts of clay and fulphur, which is reduced to alum during calcination, by expofure to air. He likewife found a little martial earth, to which he afcribes the reddifh colour of the alum; and a little vegetable alkali." (*Journal Phyfique, Supplement*, p. 338). Morveau.

may

may be obtained : for the vitriol being separated by cryſtallization, there remains alum, together with vitriol ſo much dephlogiſticated, that it cannot concrete ; the baſe of this, therefore, was ſeparated by the alkaline lixivium ; and the ſolution, properly evaporated, yielded alum.

§ v.   *The Preparation of Alum includes a Number of Operations.*

After the foregoing obſervations, we ſhall be able the more eaſily to underſtand the different circumſtances neceſſary for the preparation of alum.   The mechanical parts of the proceſs I paſs over, as not immediately belonging to our ſubject.   The firſt chymical operation which occurs is one of the chief ; namely, the preparation by which the matrix is either made aluminous, or at leaſt fit for elixation : the next is, the extraction of the alum by water, then the cryſtallization, and finally the depuration ; unleſs all the operations be performed both with ſkill and accuracy, the alum obtained will be deficient either in quantity or quality : we ſhall therefore examine them all ſeparately, and, by diving as far as poſſible into the nature of them, diſcover the circumſtances neceſſary to be attended to.

§ vi.   *The Calcination and Roaſting of the Ore.*

The bituminous ore, in its found and natural ſtate, contains indeed the vitriolic acid,

and

and the argillaceous matter, but not yet combined. In order that the pyrites may yield its acid for that end, it is neceffary that it fhould be deftroyed; and this may be effected either by a flow fpontaneous calcination, or by roafting, which laft requires lefs time.

(A) The deftruction of the pyrites is neceffary, that its fulphur may be deprived of phlogifton; for when that is diffipated, the vitriolic acid, being fet at liberty, attacks partly the iron, partly the clay: the vitriol generated is fo far deprived of its phlogifton by age, that clay is able to take away the menftruum from the iron (x. B), but pyrites fuffers no fuch change, fo long as it remains dry, and fhut up from the accefs of free air; — the conditions then neceffary to fpontaneous calcination are eafily found to be the following:

1ft. The ore ought to be of a loofe texture, that it may be penetrated by the air, and the moifture: the Swedifh ores, on account of their hardnefs, can fcarcely be treated in this way, unlefs they be firft pulverized, which occafions too much trouble: but the earthy ores are not only unfit for this purpofe, but for roafting, as they extinguifh the fire.

2dly. That there be a determinate accefs of moifture and air, for too much or too little is injurious;—too much water deluges the mafs, and excludes the air; too little, befides being infufficient in quantity, acts

more

more flowly; and upon thefe circumftances depends the proper adjuftment of the fize of the heaps: a moderate accefs of air is moft proper, as too great a one dries too faft; experience only can determine what is fitting upon different occafions.

3dly. The bottom on which the ore is laid for fpontaneous calcination fhould be of clay, or at leaft fo compact as that water can hardly penetrate it, and befides furrounded with a trench to receive the rain-water, when fuperabundant; the fides and bottom of this trench muft be fo conftructed that they will not fuffer the elixated faline matters to pafs off;—if the ore be fet to calcine in a houfe, the laft caution is unneceffary. As the nature of the ores, and local circumftances, are liable to much variation, general rules cannot be eftablifhed, but the operator muft be determined *pro re natâ*; and in this, whoever underftands the nature of the materials, and of the operation, will find no difficulty.

(B) The roafting is effected in a much fhorter time, by means of fire. This is generally practifed in Sweden, and is performed in the following manner:—fmall pieces of the black fchift are ftrewed upon a layer of burning fticks, to the thicknefs of half a foot; when the fticks are confumed thefe are covered, nearly to the fame thicknefs, with pieces before burned, and 4 times elixated: thus ftrata are alternately laid of fuch a thicknefs, and at fuch intervals of time, that
the

the fire may continue, and the whole mafs grow hot and fmoke, but not break out into flame; the upper ftrata may fometimes be encreafed to a double thicknefs, on account of the long continuance of the fire;—when about 8 ftrata are laid, another row is placed parallel and contiguous to the firft; when this is finifhed, a third; and fo on, until the heap is of a proper fize—it rarely confifts of more than 10 rows. The ore, when only once roafted, contains ftill fo much phlogifton, that water acts but little upon it; but when two or three times expofed to the fire, it yields its principles more freely;—nay, the roafting may be repeated to advantage, until the whole is reduced to powder. The bitumen fuftains the fire, and it is for this reafon that we ufe alternate layers of the crude fchift; and for the fame reafon, in rainy weather, the ftrata of unburned fchift fhould be thicker. An heap 20 feet broad at the bafe, 2 feet at the top, and confifting of 26 rows, is finifhed in two or three weeks, but requires two or three months to be well burned, and three weeks to cool;—the greater pyritous nuclei explode like bombs.

By a moderate and fomewhat fmothered fire, the fulphur of the pyrites is flowly confumed, and the phlogifticated acid, penetrating the mafs, is fixed; after which the remaining phlogifton is gradually diffipated. The chief artifice is moderating the heat fo as to avoid with fafety the two extremes;

namely,

namely, left, on the one hand, the ore be
either infufficiently or too flowly prepared
by a weak heat ; and on the other, left either
the neceffary acid be diffipated by too in-
tenfe a fire, or the pieces of fchift melt and
vitrify. The fcoriæ cannot be penetrated
by water, and are therefore rejected as ufe-
lefs ; thefe are occafioned either by violent
winds, or a ftrong heat, too much clofed ;
for holes muft be opened in the red ftrata,
that the fire may reach to the black ftratum
which is to be laid on.

At Garphyttan a new method is employed,
depending upon a peculiar conftruction of
the furnaces, invented by the celebrated Rin-
man.—There the ore itfelf is fet on fire, and
when burned is boiled, and yields alum in
the fame manner as when burned in the
ufual way : I have not yet had an opportu-
nity of comparing the falts produced by
thefe two methods ;—it appears probable
that more of the acid is diffipated by the
open flame : however, although lefs falt be
obtained in the laft way, yet, with refpect to
fuel and labour, there will be a confiderable
faving.—The heaps are thus formed :—firft
the fchift, burning from the furnace, is laid
to the depth of four feet ; if the fire be
flow, wood is added ; then a thin ftratum of
elixated fchift ; the third confifts of fchift
not burned ; and the fourth of elixated fchift,
a foot and a half thick ; after that the burn-
ing fchift ; and fo on as before.

It

It muft be confeffed, that the conveni-
ences in this procefs are fomewhat balanced
by inconveniences; for fo great a quantity
of fchift is requifite to fuftain the flame,
that it cannot all be elixated: hence, fo
long as this method is employed, we have
an heap, which can never be ufed, perpe-
tually accumulating.

In fome foreign manufactories fire is
firft employed, and afterwards fpontaneous
calcination : it is impoffible to determine
generally which is the beft method, as that
entirely depends upon the nature of the ore,
and other circumftances.

(c) As to the hard ores which contain
no bitumen (fuch as thofe of Tolfa) thefe
are burned upon wood for fome hours, like
lime-ftones, until by cracking they grow
pervious to water, and efflorefce. As foon
as the flame grows white, and the fmell of
phlogifticated vitriolic acid appears, the fire
is extinguifhed. When the ore grows cold
thofe particles which were neareft to the fire
are placed outermoft, and thofe which had
been outermoft, within; and the fire is again
lighted. It is better to burn too little than
too much, left the vitriolic acid be expelled:
the ore is fufficiently burned when it can be
broken by the hands.—The ore is then
heaped up near certain trenches, and is wa-
tered about five times a day, and particu-
larly when the fun fhines clear; a conti-
nued rain and cloudy fky ruin the operation.

A a 4   When

When the ore can be reduced to a paste in the hand, it is fit for boiling (¹).

The powdery ore sometimes requires no preparation, yet at the manufactories of Puteoli they frequently enrich it in this manner :—they heap up the larger pieces, where the vapours of phlogisticated vitriolic acid break forth, and when well penetrated with this, they yield a larger quantity of alum.

§ VII. *Elixation of the Ore.*

(A) The ore, enriched with alum, and made pervious to water, is boiled, and that in various ways at different places.—At Puteoli it is performed in the most commodious manner : a leaden cauldron, buried in the ground, is filled with the ore (which is often dug out to make room for the cauldron) and water being poured on, it soon becomes well impregnated with alum by the heat of the sun, which here arises to 46° (²). At Tolfa the calcined ore is thrown into the cauldron, and boiled.

(B) In ours, and many foreign manufactories, a cold elixation is performed. I shall give some account of the method which was

(¹) The accounts differ. Mazeas says, that water is poured on the burnt ore 14 days (*Scav. Etrang.* t. v.) Fougeroux, whom I have generally followed, says 40 (*Mem. Paris.* 1766) ; Angersten, 14, and at most 20. So also with respect to the time of burning, Ferber says it is 3 hours, Fougeroux 12 ; and he mentions that it is repeated. Ferber speaks of urine and chalk being added, &c. Perhaps the process was different at different times.
(²) Nollet Mem. Paris, 1750.

ufed at Garphyttan, in the year 1772 :—the receptacles deftined for this purpofe were made of hewn ftone, and the joints clofed by fome fit cement (in other places they are wooden veffels) ; every fet confifted of four fquare receptacles difpofed in a fquare, round a fifth, which was deeper than the reft ; the firft receptacle is filled with roafted fchift, and (water being poured on it) lies for 24 hours ; the water is then drawn off by a pipe into the fifth, from thence into the fecond, containing fchift not yet wafhed ; from that, in like manner, after 24 hours, through the fifth into the third, and fo into the fourth ; the lixivium then is conveyed to and let to ftand in the fifth ; and finally, from thence is drawn off into a veffel appropriated to its reception :—thus the fchift is wafhed with frefh water four fucceffive times.

In other places (and originally at Garphyttan) the water firft paffes over the fchift that has been already wafhed three times for fix hours, then that which has been twice wafhed, next what has been once wafhed, and laftly, the ore that has been juft roafted. The perfons who fuperintend thefe manufactories think that the alum, which the water firft paffing over the new burnt fchift takes up, perifhes if it be again poured on that previoufly elixated.—This phænomenon, if it be true, is worthy of attention ; but I have not had an opportunity of examining it.

(c) Care

(c) Care fhould be taken to fave fuel as much as poffible; it is therefore of great moment to have the lixivium, before boiling, richly impregnated with alum; for the more rich it is when poured into the boiler, the fooner it is cryftallized: it fhould not therefore be put into the boilers until faturated when cold. This faturation is neglected in fome places, where every thing is tranfacted without deviating from the manner firft ufed; in other places the tafte is employed as a criterion; but thofe who examine more accurately, make ufe of a balance in this manner:—the weight of water which fills a fmall glafs bottle is divided into 64 parts, each of which is called a *panning*; and the quantity by which the fame bottle, full of lixivium, exceeds it when filled with water, is fuppofed to indicate the quantity of falt diffolved: and thence they form their judgment (³).

This method, properly corrected, is fufficiently accurate.—The divifion into parts is arbitrary; but the moft commodious divifion with refpect to the weights in ufe, and the calculation, ought to be chofen: I fhall therefore give fome general formulæ:— let the capacity of the bottle expreffed in cubic inches be m; n the number of parts into which it is thought proper to divide it: let a cubic inch of diftilled water weigh

(³) Act. Stockholm, 1743.

422,5 grains; then the weight of one panning will $= 422,5 \frac{m}{n}$; that of the whole capacity filled with water 422,5 m ; that of alum of the fame bulk as a panning $= 874,9 \frac{m}{n}$: when the lixivium which fills the bottle is $= 422,5 \, m + 422,5 \frac{m}{n}$, it is then immediately concluded that the quantity with which the water is loaded is $= 422,5 \frac{m}{n}$; but erroneoufly, for recent experiments fhew, that falts diffolved always ([4]) increafe in bulk ; and if this be always done in the fame proportion, and the whole increment be fet down aluminous, $422,5 \frac{m}{n} + 452,4 \frac{m}{n} = 874,9 \frac{m}{n}$, will exprefs the true quantity diffolved. And in general if p denotes the number of pannings found in the fcales, the alum contained in the bottle will be $874,9 \frac{mp}{n}$, and in the kanne $87,490 \frac{p}{n}$.

But to return to the common practice :— the perfons who fuperintend the works contend, that the cold lixivium ought to be made no richer than when the fuperpondium is equal 45 pannings, which, according to our computation, fhews the water to be loaded with $\frac{1}{5,7}$ of its own weight. They affert, that if the fuperpondium amounts to 6 pannings, which is $\frac{1}{4,8}$, the cryftals are depofited. Thefe propofitions cannot hold equally good during the whole time that

([4]) R. Watfon. Phil. Tranf. 1770.

the work is going on, as the temperature of the atmofphere varies much during that time. We fhewed before that diftilled water, in a moderate heat, takes up about $\frac{1}{14}$ of its own weight, which, upon computation $= 2\frac{1}{2}$ pannings, therefore $\frac{1}{5,7}$ cannot be taken up, unlefs in a heat more than moderate. But we muft obferve, that in the bituminous minerals, befides the alum, there is always vitriol of iron, which is more foluble; there is alfo fometimes vitriolated magnefia; and befides, the more fubtile earthy particles, mixed mechanically during the operation, remain long fufpended, unlefs the lixivium be filtered.

The water is generally impregnated by a fufficient quantity of the prepared ore: it feems probable that more would be obtained by hot than by cold water; but this is denied by thofe who daily attend thefe operations (e).

(D) From what has been faid it appears that the gradual operation, as it is called, can hardly be ufed to advantage in the alum works, as, of all the contents of the lixivium, alum is the moft difficult of folution.

Congelation is here of no ufe; for water faturated with alum freezes almoft as readily as fimple water: and all other falts prevent congelation more than alum.

(e) M. Morveau wonders that an aerometer is not employed, in order to determine the concentration of the ley. B.

In rainy weather the lixivium ought to be well covered; but I do not find in any manufactory provifion made for this accident.

§ VIII. *Decoction of the Lixivium to Cryftallization.*

Let us now fuppofe the firft fpring boiling beginning: the frefh lixivium, of a proper ftrength, is brought from the pits, through canals made for the purpofe, to the houfe deftined for the boiling; there it is put into a leaden boiler; at the back of this is placed a receptacle, out of which the lofs fuftained by evaporation is continually fupplied; fo that by this artifice the furface of the lixivium in the boiler neither rifes nor falls, but continues at the fame height.

Some take the floating of a newly laid egg as a token of boiling being finifhed.— The fpecific gravity of fuch an egg is about 1,081; but in a few days, efpecially in warm weather, it fuffers a confiderable change:—but fuppofing its fpecific gravity conftant, yet a confiderable difference will occur, unlefs the magnitude of the part above the water be afcertained.

Others drop a fmall quantity on a plate, and obferve whether it cryftallizes on cooling.

Finally, others weigh the lixivium in the bottle above mentioned, and confider the

3   boiling

boiling finifhed, if the increment of weight be equal to 20 pannings; that is (according to our computation) if the water be loaded with $\frac{1}{1,69}$ its own weight. Now we faw that it could take up above $\frac{1}{3}$ its own weight (§ 11.) that is, nearly equal to 27 pannings; but the lixivium cannot be fo much loaded, as it muft be depurated by ftanding quiet, before any cryftals form (f).

The lixivium, fufficiently concentrated by evaporation, flows through channels into coolers, where, in about an hour, it is freed, by depofition, from the groffer heterogeneous particles; it is then put into either

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(f) Nothing would be more advantageous for judging with precifion concerning the degree of boiling which the leys have undergone, than the aerometer. This inftrument fhould be made of metal, that it might be lefs liable to be broken; it fhould have fufficient ballaft, that it might fink into the liquor, and ftand upright; and after having once marked upon the ftem the degree at which it ftands in a ley fufficiently concentrated, it might be hit again with certainty, and the flighteft infpection would be fufficient. I contrived fuch an one fix or feven years ago for a fugar-refinery; a procefs in which the degree of boiling is ftill more important. This was determined before by putting a drop of the liquor upon the nail, and drawing it out into a filament, to expofe it more completely to the contact of the air; infomuch that the moifture, heat, and agitation of the atmofphere, befides other accidental circumftances, concurred to render this fign very equivocal. The conductor of the work affured me, that this inftrument had been very ufeful to him; and I know that it was afterwards introduced into other refineries. M. Baumé had before advifed the ufe of it, in order to judge of the infpiffation of fyrups (*El. de Pharmacie*, p. 555). Morveau.

ftone

ftone or wooden receptacles. In eight or ten days the lixivium, commonly called magiftral water, flows into another veffel, leaving behind a number of cryftals, generally fmall and impure, which incruft the bottom and fides of the veffel. Thefe are collected, and wafhed from the impurities which adhere externally, with cold water: the impurities remaining in the refervoir after wafhing, are kept by themfelves.

(B) The wafhed cryftals are put into the boiler ufed for depuration, and are diffolved in a quantity of water fo fmall that it may, when boiling, be able to take up all the falt, and be fufficiently loaded with it : the lixivium is then poured out into a great tub, which holds the fame quantity as the boiler does. After 16 or 18 days the hoops of the tub are loofed, and the aluminous mafs is bound with an iron ring: after 28 days the refiduum of the folution is let out through a hole, and collected in a trench ; the aluminous mafs, then dried, is called depurated alum, and amounts, at Garphyttan, to 26 tons.

(c) Let us now look to the boiler emptied for the firft cryftallization. This is directly filled two thirds with the magiftral lixivium, which is brought to the boiling point ; and as foon as it arrives at that, the empty third is loaded with the crude lixivium, with which alfo the wafte of evaporation is continually fupplied. The boiling being

being finifhed, a certain quantity of alumi-nous impurities is added, after the folution of which, by continual agitation, the lixi-vium is let out as before. The firft boiling in the fpring, is performed with the crude lixivium alone ; the reft in the way above defcribed.

As to the time required for cryftalliza-tion, it may without doubt be fhortened, efpecially when the furface is fmall with refpect to the mafs, as is the cafe in our ma-nufactories ; for the refervoirs ufed in the firft cryftallization are deep and very nar-row at the top, and the fame is the cafe to this day in the fecond cryftallization. The heat of the mafs, therefore, being reduced to the temperature of the furrounding atmo-fphere, the evaporation, and of confequence the depofition, is very flow, except when the weather is exceeding warm, and befides the doors and windows fo difpofed that a current of air continually runs along the furface. The cafe is quite different in fmall experiments, efpecially in conical glaffes, where the furface is very large with refpect to the mafs. In Italy conical refervoirs are ufed, and indeed with the greateft pro-priety.

(D) In order to obtain the alum more pure at the fecond cryftallization, in fome places additions are employed, fuch as alkalis, lime, or urine ; for the experience of many years has fhewn, that the lixivium fome-.

<div align="right">times</div>

times acquires such a consistence, that it both crystallizes with difficulty, and produces impure crystals : pot-ashes, particularly, were used to prevent this inconvenience, because the acid is superabundant. Pot-ashes and lime, either burnt or crude, absorb the acid ; and, if added in proper proportion, diminish the quantity of heterogeneous noxious matter, by precipitating them : this will appear clearly, from considering the nature of the lixivium ; but urine has no effect, except in so far as it contains volatile alkali. It is not to be denied, that new salts are in this case mixed ; namely, vitriolated vegetable alkali, or others, according to the nature of the additament ; these are undoubtedly more harmless than those which are taken away, but yet are not to be sold for alum.

(e) The Roman alum has been considered as the best sort : at Brunswick some time since they began to manufacture a species of alum, which, if we give credit to report, may properly be substituted for the Roman. I have examined this alum chymically, and found it mixed with cobalt (1). I have no doubt but the ore of cobalt roasted, is mixed with the lixivium ; for in that case the disengaged acid attacks the metallic calx, and forms a rose-coloured solution, which gives a tinge to the crystals. This alum, dissolved in water, yields, upon adding a fixed alkali, an urinous salt ; with

(1) I see that Erxleben has observed this in his Essays.

B b   phlogisti-

phlogisticated alkali, discovers iron, but not cobalt; which last is manifested by the violet colour, on fusing the precipitated base with borax :—it is distinguished from the Roman alum by its crystals, which are all tinged, acerb, and less acid than the Roman. A crystal of Roman alum exposed to heat by the blow-pipe, soon grows opake, swells, and foams, but a spongy, immoveable, white mass soon appears; whereas the Brunswick swells less, hardly foams, but melts, and at last grows green; besides, from the very beginning, it sends forth copiously an arsenical smoke.

I do not deny that I have sometimes got a green glass from the rose-coloured base of alum, which would indicate the presence of cobalt, if it always happened; but after once finding it, I have tried 100 times again to no purpose: what this colouring principle is, is still doubtful; but we know for certain that the goodness of the alum does not depend upon it.—I have not yet had an opportunity of examining the use of Brunswick alum in dying (g).

(g) I have already mentioned Mr. Monnet's conjecture concerning the cause of the reddish colour of Roman alum. By analysing the beautiful red selenite from Montalier in Franche Comté, which is crystallized in shining lamellæ, and from which I have obtained iron in its complete state, I am convinced, not only that this metal can communicate all the shades of this colour, but also that it adheres very tenaciously to vitriolic earthy salts; for, after boiling this selenite in distilled water, and filtering the solution, a deposition, having a slight tinge of this kind, took place as the liquor cooled. Morveau.

(F) At

(F) At Tolfa the lixivium, agitated in a veffel, is infpiffated by boiling for 24 hours (*h*) ; this being done, the fire is extinguiſhed, the earthy parts are taken away by inſtruments provided for the purpofe, and the liquor, after being cleared by fubfidence, is let out by a cock into a receptacle made of oak ; there it cryſtallizes for 14 days ; it is then let off into ſhallower receptacles, where it depofits more cryſtals ; and, finally, is let out in the magiſtral trench. In this procefs no depuration is effected by cryſtallizing ; and therefore the Roman alum contains in 100 lb. upwards of 5 lb. of a rofe-coloured earth :—100 of the ore never yields 2 lb. of alum.

The magiſtral lixivium appears unctuous, and difficultly forms cryſtals ; yet, in broad and ſhallow veffels, it yields genuine alum, although a flow fpontaneous evaporation is neceffary.

At Puteoli the lixivium digeſted by the folar heat forms at length on the furface cryſtals, which, being collected in a conical ſtone receptacle, are again diffolved in warm water ; and there, the evaporation going on by the natural heat, more pure cryſtals are formed : in this cafe the ore yields more than 40 lb. of alum in 100, but generally mixed with iron.

(*h*) Travellers do not agree concerning the metal of which the boiler is made. Angerſten fays that the bottom is of copper and the fides of ſtone, Ferber mentions copper only, Fougeroux fays the bottom is of lead, Mazeas, that the boiler is of lead.

§ IX. In

§ IX.

In order to difcover the differences of the feveral lixivia more accurately, I began by examining the three principal ; thefe are, that which is made of the roafted ore, faturated with falt in the cold, and which is called the crude lixivium ; that lixivium which remains after the fecond cryftallization of the alum ; and, finally, the laft lixivium, which is commonly called magiftral. Thefe lixivia muft neceffarily differ more or lefs in different places, according to the nature of the ore employed, and the varieties of the operation : and even fuppofing the ore to be the fame, and equally roafted, yet the firft is the richer, from the greater heat of the atmofphere ; the fecond, through the whole year fuffers the fmalleft variation ; and the laft the greateft, as being, from the beginning of fpring till late in autumn, continually loaded with foreign matters ; therefore, although a great variety neceffarily occurs, yet it will be ufeful to confider a fet of experiments which were made upon lixivia got at Garphyttan in the month of September 1776, and carried well corked to Upfal.

(A) The fpecific gravity of the crude lixivium in a moderate heat, was to that of diftilled water as 245 to 215 : this fpecific gravity indicates 9 pannings.

At the bottom of the bottle was collected a yellowifh powder ; the lixivium was yellow, a little greenifh, had an áluminous

2   tafte,

tafte, but fomewhat auftere and earthy. Paper tinged with turnfole grew red when wetted with this lixivium ; but the deep blue paper ufed for fugar was not changed.

Phlogifticated alkali immediately precipitated a Pruffian blue, in the proportion of 930 grains to the kanne : this indicates nearly 809 grains of vitriol.

Fixed alkali, dropped in by degrees, precipitated firft a ferruginous yellowifh powder, then a white one ; but that which falls on the addition of a few of the firft drops, is by degrees again diffolved ; hence we may judge of the fuperabundance of acid ;— how great that fuperabundance is, we fhall fee in the fequel :—the acid of fugar occafioned no change.

In this lixivium there are prefent vitriol, alum, and vitriolated magnefia ; falts which are not feparable from one another, but with great difficulty. I firft tried to effect this feparation by fpontaneous evaporation ; when this can be done, diftinct cryftals generally appear (a very long time is indeed requifite) ; and, in the mean time, the atoms which float in the atmofphere mix with the liquor ; but to avoid thefe inconveniences, I ufe broad veffels which expofe a large furface to the air ; and as evaporation proceeds, *cæteris paribus,* in proportion to the furface, the delay is much diminifhed. In order to exclude duft, a very thin filk, or a large glafs bell, may be put over

B b 3   the

the liquor: by this method I obtained from a kanne of the lixivium 1,933 grains of cryftallized alum, and of a fhapelefs acid faline mafs, 5,790 grains; thefe were dried upon bibulous paper;—even the cryftals themfelves, upon the addition of phlogifticated alkali, yielded Pruffian blue; I therefore tried another method of feparating the falts, and that with better fuccefs:—

I firft precipitated the iron with phlogifticated alkali, then the earthy part with fixed alkali, in order to take up the fuperabundant acid; I again diffolved this earth, when wafhed, in vitriolic acid, the gypfum remained at the bottom; I weighed the liquor, filtered, cryftallized, and dried; I totally deftroyed the aluminous part of the falt remaining, by chalk; and, finally, filtered and cryftallized the liquor which remained; this produced nothing but vitriolated magnefia.

I determined the quantity of fuperabundant acid in the following manner: I added fmall pieces of cryftallized fal fodæ, thefe foon grew red from the precipitated iron, but were foon diffolved; I continued to add the alkali, until fome remained undiffolved; at the fame time I faturated a known weight of that vitriolic acid, commonly called oil of vitriol, with the fame alkali, and hence learned to compare the fuperabundance with the quantity of this oil.

Thefe experiments fhewed that there were, in

in each kanne of the crude lixivium, 15 grains of gypfum, 3,889 of vitriolated mag-nefia, 2,933 of alum, 809 of martial vitriol, and fo much difengaged acid as was equal to 72 grains of common oil of vitriol.

The vitriol of iron which appears here is of a peculiar nature, for the lixivium does not depofit an ochre on boiling, or on fpontane-ous evaporation to drynefs, but holds its co-lour perfect; yet that it contains iron very much dephlogifticated, is eafily gathered from the ferruginous colour of the martial precipitate, occafioned by a fixed alkali: the cafe is very different with a folution of com-mon vitriol.

§ x.

From the preceding paragraph, it evi-dently appears, 'that there is prefent in the lixivia a greater quantity of acid than is ne-ceffary for the formation of alum. The quef-tion is, whether this impedes the cryftal-lization, or promotes it? Many, among whom is the celebrated Margraaf, affert the former; but an experiment publifhed in 1744, by Mr. Baron, fuggefted the latter opinion to fome.—The experiment is this: concentrated vitriolic acid, added in large quantity to a folution of alum, precipitates the alum, by feizing the water; which be-ing quickly cryftallized in this intenfely acid folution, frequently exhibits cryftalline fpi-culæ, or needles diverging from a point, like

ftars.

ftars. This, in the fame circumftances, happens to many falts : — highly concentrated vitriolic acid is able to take away from alum not only the water of folution, but the water of cryftallization. Let a tranfparent piece of alum be put into fuch an acid, and in a few minutes it will be found to grow white and opaque : thus we have what may be called alum calcined by the humid way ; and this phænomenon is a teft of the perfect concentration of vitriolic acid.

But in the prefent cafe there is no queftion of fo great a quantity of acid as is able to take away from the falt its diffolving water : the moft highly concentrated vitriolic acid feems to be faturated with about double its weight of water (at leaft it attracts no more from the atmofphere) : but we are now enquiring concerning a quantity which has united to it far more than twice its weight of water, which therefore muft adhere but loofely, as being fuperabundant.

Every day's experience fhews that vitriolated vegetable alkali and gypfum are more copioufly diffolved, if the water be fharpened by a fmall portion of vitriolic acid ; nay, the nitrous acid has the fame effect ; and in geral this holds good of all falts hitherto known, excepting only tartarized tartar, and thofe which agree with it in qualities; for this falt, when the proportion of acid is encreafed, degenerates into tartar which is far more difficult of folution. It would be fcarce

worth

worth while to demonſtrate that alum agrees with the other ſalts in this reſpect, were it not that it has been called in queſtion. —What follows, will, I hope, elucidate that matter ſufficiently (*i*).

(A) I choſe 12 glaſſes of a conical figure, as nearly ſimilar and equal as poſſible; to the firſt, I did not add any vitriolic acid; in the ſecond I put 4 drops; in the third 6; and ſo on, as the following table ſhews; where the column marked *number of glaſſes*, ſhews the number of drops put into each—(100 drops weigh about 113 grains); this being done, an equal meaſure of a ſolution of alum filtered, was put into each glaſs: — I employed Roman alum, and therefore filtering was neceſſary, to ſeparate the earthy part. The glaſſes were ſet in a place where the thermometer ſtood during the whole experiment (which laſted 25 days) between 6° and 10°: after the 1ſt, 2d, 6th, and 25th days, whatever was found cryſtallized was taken off with a ſilver ſpoon, and dried for 10 hours, upon a bibulous paper folded, and was then weighed. In order to avoid fractions, I expreſs the weights in docimaſtic pounds, 400 of which are equal to 215 grains.

(*i*) See the Stockholm Tranſactions, in which I firſt publiſhed theſe experiments.

Number of glasses.	After 1st day.	After 2d day.	After 6th day.	After 25th day.	Sum total.
0	50	5	3	18	= 76lb
4	39	13	2	17	= 75
6	38	11½	2	18	= 69½
8	30	14	1½	16	= 61½
12	30	13	1	17	= 61
16	20	19	1	18	= 58
20	20	16½	1	20	= 57½
24	14	22	1	20	= 57
30	14	22	1	20	= 57
40	15	18½	1	23	= 57½
50	12	23	½	23	= 58½
100	16	25	½	24	= 65½

(B) I repeated the experiment, only making use of five glasses; into each I put one half the measure of filtered solution of alum, and the number of drops of the acid indicated in the first column beneath: 100 drops, now weighed about 92½ grains. The experiment took up 23 days; at the end of which time all the moisture in the first glass had evaporated.—The temperature was between 15° and 20°.

Number of glasses	After 1st day.	7 days.	12.	23.	Total.
0	199	30 grs.	44 lb.	56 lb.	= 329 lb.
25	190	21	52	64	= 327
50	172	29	53	66	= 320
75	166	17	52	67	= 302
100	163	26	50	58	= 297

Hence

Hence it eafily appears that the fmall-eft addition of acid impedes the cryftal-lization : a comparifon of the 3d, 4th, and 5th column, will indeed fhew many irregularities, which may be exhibited by a curve, by erecting, perpendicular to the axis, ordinates proportioned to the number in each column, and by taking the abfciffæ proportional to the numbers in the firft column. Thefe irregularities can hardly depend entirely on the inequality of the cups; but undoubtedly they depend, at leaft in part, upon the different relative proportions of the alum, water, and acid ; befides, a perfect equality cannot be preferved in a number of drops : but this does not affect the general conclufion ; for if by accident, where the difference is fmall, 4 fhould $= 6$ in weight, this will not happen where the difference is greater, without remarkable negligence.

Befides, I took as much care as poffible that the folution poured into the laft glafs fhould be as warm as that in the firft. If any variation happened here, it muft have arifen from the latter glaffes being richer than the former, on account of the contraction of bulk by cooling.

That the evaporation fhould proceed fenfibly during the whole time of the procefs, the broad furfaces give reafon to expect, and all the phænomena demonftrate that it was fo. It is otherwife in the manufactories (§ VIII. c).

(c) To

(c) To avoid the exception arifing from the inequality of the drops, I made the experiment in the following manner :—I diffolved 215 grains of pure alum in diftilled water, in a fmall cucurbit, and evaporated over the fire until the furface of the liquor correfponded with two oppofite marks on the narrow neck, which, according to former experiments, indicated that the warm folution was fit for cryftallization ; I therefore poured it out into a glafs : in the fame cucurbit, after wafhing it, I again diffolved and evaporated 215 grains, with the addition of 24 grains and an half of concentrated vitriolic acid ; this folution was poured out into a glafs fimilar and equal to the former. I repeated the experiment a third time, with no other alteration than the addition of 53 grains of vitriolic acid. The glaffes were then all fet clofe together, in a place the temperature of which was 10°. After 56 hours I collected the cryftals, and left them untouched for 12 hours, upon bibulous paper many times doubled ; at the expiration of that time I found the weight of cryftals obtained from the firft cup to be 155¾, from the fecond 130 ; and from the third only 100¼.

(D) The laft objection is, that the vitriolic acid attracts water very ftrongly, and therefore no other way impedes cryftallization than by taking away the water neceffary for the folution. The queftion is not at

prefent

prefent in what manner the vitriolic acid
acts; and therefore, without giving up my
thefis, I might allow this conjecture to be
right; but I took that opportunity of ex-
amining into its truth : for this purpofe I
provided two equal and fimilar bottles, A
and B; into each I put eight ounces of dif-
tilled water, and into B only I put $50\frac{1}{2}$ grains
of vitriolic acid; I afterwards added to each
equal portions of powdered alum, and im-
mediately clofed them both well. As long
as none remained undiffolved I continued to
add more alum, and did not ceafe, until a
portion remained for fome days, which the
liquor was incapable of diffolving. Equal
portions of the falt were always more
quickly diffolved in B than in A. The wa-
ter in A diffolved only $339\frac{1}{2}$; that in B 373;
and $80\frac{1}{2}$ more upon the further addition of
$134\frac{1}{2}$ of vitriolic acid.

Since then the folution is as it were in
the inverfe ratio of cryftallization; and as no
difference in evaporation could take place,
the bottles being nearly full, placed near
one another, and well ftopped; I conclude
that the acid of itfelf encreafes the folubili-
ty, or, which is the fame thing, impedes the
cryftallization.

§ XI.

After having fhewn, by many experiments,
that the cryftallization is impeded by the
fuperabundant acid, the queftion now is

concerning

concerning the moſt commodious method of detaching that ſuperfluity.

(A) Alkaline ſubſtances, ſaline or earthy, are no doubt capable of ſuppreſſing it, but theſe ſuperadd a ſalt of another kind. It ſometimes happens, that alum does not yield firm cryſtals, a fact firſt obſerved by M. Margraaf, who alſo ſhewed, that this inconvenience aroſe from a ſmall quantity of vegetable alkali. I know that, without any addition, complete cryſtals may be obtained; but for the moſt part, unleſs the evaporation be carried on extremely ſlow, the great portion which remains after the depoſition of a few perfect cryſtals is nothing but a ſaline magma. It is remarkable that this impediment to cryſtallization is equally well removed by volatile alkali, but not by mineral alkali, or by lime (and this points out the reſemblance between vegetable and volatile alkali, as alſo between mineral alkali and lime, a reſemblance which we ſhall ſee elſewhere (*k*) : not only the common, but even the Roman alum, when precipitated by a volatile alkali, yields a liquor which not only contains an ammoniacal ſalt, but frequently a vitriolated vegetable alkali ; which latter may be had alone, the former being ſeparated by ſublimation. The preſence of this alkali is owing either to the clay itſelf being adulterated with the reſiduum of putrified vegetables, or from aſhes,

(*k*) Diſſertation on Platina, vol. ii.

either

either added on purpofe, or accidentally mixed, during the calcination and roafting. In the mean time, it is certain that alum and vitriolated vegetable alkali eafily unite, and thus a triple falt is formed : the alum, deprived of this addition, is unfit for making the pyrophyrus, which may be eafily tried ; for the aluminous magma which refufes to cryftallize diftinctly, yields, when treated in the ufual way, not a particle of pyrophyrus ; whereas it yields an excellent one, upon the addition (*l*) of a fmall quantity of vegetable alkali (*m*).

Thefe circumftances fuggeft a fufpicion, that vegetable alkali is neceffary for the perfection of alum ; and that therefore all perfect alum fhould be confidered as a triple falt ; but this conjecture is not well founded, as the fame perfection may be obtained by the volatile alkali, and a fpontaneous evaporation. However, I do not fuppofe the addition of vegetable alkali improper, provided it be pure ; for if impure it is more noxious than ufeful. The whole of the

(*l*) Vid. Scheele on Fire.
(*m*) It is difficult to imagine how this alkali contributes to the production of pyrophorus, more efpecially fince M. Prouft has fhewn, that it may be obtained without alum, and even without vitriolic acid ; that the refiduum of faccharum faturni, after diftillation, cryftals of verdigreafe, and feveral other metallic falts, are true pyrophori ; in a word, that almoft every fubftance which leaves, after its decompofition, a coally matter, fimply divided by an earth, or a metallic calx, has the fame property (*Journ. Phyf.* 1778, *Suppl.* p. 432). Morveau. See Prieftly, vol. iii. and iv. Appendix.

fuperabundant acid, however, muft by no means be faturated with alkali, as the alum would in that cafe be too much mixed with a foreign falt, and the operation be rendered expenfive, without gaining any advantage.— Urine ought to be avoided, partly on account of the heterogeneous matters which it contains, partly on account of the volatile alkali, which communicates to alum properties that render it unfit for the purpofes of dying.

(B) But as a pure clay conftitutes the bafis of alum, the fuperabundant acid cannot by any other means be more conveniently reprefied than by this earth; which, at the fame time that it prevents the noxious fuperabundance, increafes the quantity of alum. I am very much furprized that fo excellent and obvious a remedy has never been propofed by any perfon, at leaft fo far as I know.

In order to afcertain what was to be expected from this, I inftituted feveral experiments, by which the truth of the above affertion was fufficiently evinced. It will be fufficient to relate two:—I employed a magiftral lixivium, in which the excefs of acid was nearly in quantity as defcribed (§ IX. c.); to a kanne of this I added two drachms of pure clay, reduced to a fine powder, and moiftened with a few drops of water: I then applied the heat of ebullition, which I continued for ten minutes; when all was

cold

cold I feparated the clay that remained, and upon wafhing and drying I found that 25½ grains were diffolved; which indicates an increafe of alum of 141 grains (§ III. B). At another time I employed gentle boiling for half an hour, by which 75 grains were taken up, fo that 416 grains of alum were pro- duced; hence a fingle boiler would produce 1,400 ounces.

I entertain no doubt, therefore, but that the addition of clay is extremely ufeful; and this fhould be done at the very firft, when the lixivium is put into the boiler; a clay free from lime is neceffary, as this laft would produce gypfum; it muft alfo be free from any thing vitriolic. In general the quantity is to be regulated by the quan- tity of fuperabundant acid; and we muft confider that the earth of alum frequently conftitutes only one fourth of argillaceous earth. A few trials will, in the prefent cafe, be fufficient to direct us.

§ XII.

Many circumftances relating to the me- thod of obtaining alum pure have been mentioned in the foregoing fection, where we treated of repreffing the fuperabundant acid.

Alum, as it is commonly made, although depurated by a fecond cryftallization, yet is almoft always found contaminated with

dephlogif-

dephlogifticated vitriol; hence it grows yellow by age, and when diffolved in water depofits ochre. This, in many of the arts, is equally ufeful with pure alum; it is even fo in dying, when dark colours only are wanted, which frequently require green vitriol: but when the more lively colours are fought, every thing martial muft be avoided, as it always obfcures them more or lefs. In fuch cafes the Roman alum is employed: it is therefore required to difcover a method by which the common alum may be fo depurated as to equal the Roman in goodnefs. The common ore, indeed, always contains more or lefs martial, which even actually enters the lixivium; notwithftanding this, however, we muft not defpair (i).

(A) Alum, made without the addition of the magiftral lixivium, both as to purity and efficacy, rivals the Roman alum, and often excels it. The crude lixivium, indeed, contains vitriol, but in fuch quantity that it is entirely feparated by the fecond cryftallization: for the alum made in this way does not fhew the fmalleft fign of iron,

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(i) " The preference given by dyers to Roman alum does not appear to me a fufficient reafon for concluding that it is not coloured by iron. It is certain, that the red felenite above mentioned does not any more fhew figns of martial earth, in confequence of the addition of tincture of galls, and Pruffian alkali, although it contains iron enough to be reduced." Morveau.

I

either

either with tincture of galls or phlogisticat-
ed alkali; besides, by the second cryltal-
lization all the earthy parts are separated,
which earthy parts always adhere to the Ro-
man. By my advice, this method was pur-
fued in two of our manufactories, and an
alum prepared superior to the Roman.

The reason is plain, for the noxious he-
terogeneous matters at first remain in the
magiltral lixivium; now, as two thirds of
this continually enter the following decoc-
tions, these matters are continually accu-
mulating, infomuch that the alum being
in the firft cryftallization overwhelmed with
thefe, can be but imperfectly freed in the
fecond; nay, a third or a fourth are fome-
times neceffary, to form as good alum as is
had without the addition of the magiftral
lixivium by means of two. How abfurd
this continual addition of the magiftral lixi-
vium is, will fufficiently appear from its
nature, and will be demonftrated more at
large in the following paragraph.

(B) If the lixivium abounds with de-
phlogifticated vitriol, (which is eafily difco-
vered by the red colour, and the continual
depofition of ochre) this is deftroyed by
the addition of clay: and let not this be
thought contradictory to the general laws
of attraction. It is indeed true that iron,
put into a folution of alum, is diffolved, and
precipitates the earthy bafe of the alum;
as alfo that, when vitriol and alum are

both

both in the fame folution, if an alkali be added gradually, and without agitation, the white argillaceous earth will be firft precipitated, and afterwards the greenifh martial earth. But this is only true of iron in a metallic ftate, or but little dephlogifticated; for if the inflammable principle be any further diminifhed, the efficacy of attraction is thereby fo much weakened, that the iron, being now calcined, will yield the vitriolic acid to pure clay. The truth of this affertion may be proved many different ways : thus, let a portion of alum be diffolved in a lixivium of highly dephlogifticated vitriol ; let an alkali be then added, and ochre will be precipitated firft, and not until after it clay ; befides, if clay be added to fuch a lixivium, and boiled, alum is formed ; and, provided there be a fufficient quantity of clay, the whole of the vitriolic falt will be deftroyed.

Thofe who are fond of wonderful tranfmutations, and accordingly fee them in every thing, will in this inftance rather fay, that the martial is commuted into an argillaceous earth : they add, to finifh the demonftration, that the falt elixated from colcothar of vitriol not only (like alum) refufes to cryftallize without the addition of a little vegetable alkali, but alfo yields tranfparent cryftals, which refemble alum in the aftringency of their tafte.

Thefe

These phænomena are true, but the con-
clusion deduced from them is erroneous.
The more frequently vitriol of Mars is dif-
solved, and again cryftallized, the more it is
deprived of its green colour, and at length
it totally loses it; hence the watery colour
of the falt obtained from colcothar : the tafte
is aftringent, like that of vitriol, but with
fome fmall difference, the metallic bafe be-
ing here deprived very much of its phlo-
gifton : befides, that the falt got from col-
cothar moft commonly does not contain a
particle of alum, there is no doubt.; for every
common vitriol owes its origin to pyrites,
which is rarely without fome clay ; there-
fore we have no occafion for a metamorpho-
fis to account for the production of alum :
but that vitriol, which is formed of iron and
pure vitriolic acid, never fhews the fmalleft
veftige of alum ; and the colcothar falt ob-
tained from fuch vitriol, upon the addition
of a fixed alkali, depofits nothing but an
ochre ; but with a phlogifticated alkali
the whole bafe is converted into a Pruffian
blue.

From all this it evidently follows, that
an aluminous lixivium, which is only con-
taminated by dephlogifticated vitriol, may
be at once enriched and depurated, by the
addition of pure clay free from vitriolic
matters.

(c) A lixivium containing perfect vitriol
cannot be freed from it to any purpofe,

either

either by clay or alkali; for the former ef-
fects no decompofition, unlefs in fo far as
the vitriol is dephlogifticated by long boil-
ing: the latter, although it can deftroy all
the vitriol, yet it cannot effect this, fo long
as any alum remains, which yields its acid
more readily.

§ XIII.

In applying the magiftral lixivium to
ufe, we muft take notice of many varieties,
the chief of which depend upon the ad-
mixture of a vitriolic falt, as this renders
the alum unfit for certain purpofes; and,
if the quantity be large, renders it un-
apt to cryftallize. However, we muft alfo
take into the account vitriolated magnefia,
which not unfrequently is found mixed
with it.

(A) A magiftral lixivium containing alum
alone, is fcarcely found any where, except
at Tolfa. Mr. Fougeroux de Bondaroi ob-
ferves, that this, expofed very much to the
air in broad fhallow veffels, by degrees,
though flowly, yields genuine alum, in
the fame way as clay artificially combined
with vitriolic acid, which, though in the
ufual way it only affords incoherent cryf-
tals, affords very complete ones by a flow
fpontaneous exficcation. I have not yet
been able to difcover the reafon of this
phænomenon; but in the foregoing pages
I have

I have mentioned, that this difpofition to cryftallize may be induced by the addition of a little vegetable or volatile alkali, but not by the mineral alkali, or lime (§ xi. A).

In the magiftral lixivia there fometimes occurs a fpecies of fat, as is judged not fo much from its vifcid appearance (which may be occafioned by the quantity of the matters diffolved) but from its nature and properties ; for a faturated folution of alum, in the fame manner as other falts, if kept long, or boiled in a glafs veffel, communicates to the glafs the property of repelling water, as if it had been fmeared with oil, and wiped with a cloth. So long, therefore, as we know no other bodies but oils which communicate this property, we muft conclude, that fomething at leaft analogous to oil is in the lixivium.

(B) The lixivium containing perfect vitriol, fo long as it is rich in alum, may be employed, as it ufually is, but only for the preparation of common alum ; whereas, if the vitriolic falt abounds, it muft either be cryftallized into a vitriol, or elfe be fo deftroyed as to produce alum, which may be done in the following way : — let the lixivium be reduced to a tenacious mafs with clay, and formed into cakes, and thefe be expofed in an houfe to the open air ; by thefe means the phlogifton, which is powerfully attracted by pure air, is by de-

grees

grees feparated from the iron, while the acid, by its ftronger attraction, takes up the clay : the calcination is accelerated by fire, but it muft be cautioufly employed, left the acid fhould be expelled : the lixivium is thus treated to much more advantage than by continued boiling, particularly when it contains but little alum (*k*), as is the cafe in our manufactories about the end of the fummer, as the noxious foreign matters are encreafed on every boiling.

(c) The lixivium, containing dephlogifticated vitriol, may be advantageoufly treated, by adding clay during the boiling : the reafon has been already explained (§ x. B), fo that we need not dwell upon it here.

(D) The lixivium, containing perfect vitriol, and vitriolated magnefia, is the moft common in our manufactories ; this may be employed in the ordinary way for the preparation of common alum, in the beginning of fummer, and fo long as the heterogeneous matters have not accumulated too much ; but when that takes place, it is proper to feparate the vitriolated magnefia ; for this purpofe it is neceffary to decompofe the vitriol, and alfo the alum, for they cannot be feparated by cryftallization (§ IX) ; this is beft done by a calcareous powder, which muft be unburnt, as, if burnt, it would alfo decompofe the vitriolated magnefia :

(*k*) Vid. Monnet fur l'Alunation.

this

this powder is to be added by degrees, left the effervescence should occasion the mass to swell over the sides of the vessel : a just proportion removes the salts, by the assistance of agitation and heat; phlogisticated alkali will readily shew whether there is any thing martial remaining. In the place of the decomposed salts there remains gypsum, but only a very small portion of it remains in the lixivium ; for, on account of the deficiency of menstruum, the greatest part falls to the bottom along with the ochre and clay. As soon as the liquor has subsided and grown clear, it must be carefully decanted into another vessel, and evaporated until a drop let fall upon a cold substance shews crystals in a few minutes ; it is then to be removed from the fire, and, on cooling, it produces vitriolated magnesia.

If in our manufactories all the magistral lixivium which is unfit for making alum was treated in this manner, we should undoubtedly obtain as much Epsom salt as is consumed in all Sweden : this salt is now imported ; whereas, if at the same time this and other means were used, we might be able to export to all Europe.

It is evident that this lixivium may also, by the methods above described, be employed for the artificial preparation of the matrix of alum.

(E) The magistral lixivium has always a superabundance of acid : we found in one

kanne

kanne nearly five ounces ; fo that in a fingle boiler there are nearly 250 lb. : but vitriol, when well dephlogifticated, retains its acid fo loofely, that it may eafily be feparated by fire. I do not doubt, therefore, but that fuch a lixivium, if its furface be firft encreafed by pouring over an heap of fticks, and afterwards collected, might be advantageoufly fubjected to diftillation.

(F) Finally, the ochre which feparates either fpontaneoufly or upon the addition of an alkali, may be made, by various methods of preparing it, to afford various pigments ; —it is enough here to throw this out as a hint.

§ XIV.

From what has been faid, I believe it will plainly appear, that if the operations were conducted with fkill and prudence in our manufactories, we fhould have, at the ordinary expence, alum better in quality, and a larger quantity. I flatter myfelf, that in foregoing fections I have pointed out the means of obtaining this end. As to the forms of furnaces, and other contrivances for more commodioufly conducting the operations, I pafs them over, as belonging rather to mechanics than chymiftry, although thefe two frequently lend one another mutual affiftance.

DISSER-

DISSERTATION X.

OF

ANTIMONIATED TARTAR.

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§ 1. *Medicines should be prescribed in such a Way, that each shall always possess the same Virtues.*

IN prescribing medicines, or in composing dispensatories, nothing is more necessary than that both the materials and method of preparation be so chosen as to be exactly alike in all cases and situations : for if the officinal preparations be not directed to be made in such a manner that they can never, under the same name, possess different virtues and properties ; or if the process be so ordered, that, notwithstanding all possible care in the repetition

of

of it, it cannot to a certainty be performed in the fame way; it plainly appears, that medicines of very different qualities may be produced by the fame formula, and that not only in different fhops, but in one and the fame. The danger hence arifing is indeed but fmall, when the lefs powerful preparations only are fubject to this inconvenience; but from what follows it will appear, that this is often the cafe with thofe which are poffeffed of confiderable activity.

For example, let us fuppofe an emetic or a purgative made by the fame formula, and, neverthelefs, that the medicine does not always produce the effect defired, that it at one time has little or no effect, at another acts moft violently; in this cafe, beyond doubt, the life of the patient is endangered, the credit of the phyfician injured, and preparations which, if rightly adjufted, would be of the moft material advantage, fall gradually into difrepute, and at length into total difufe.

All thefe inconveniences are found to take place in many officinal preparations, particularly thofe of metals, many of which, though known by the fame name, are in degree of efficacy entirely unlike.

§ II. *Antimonial Emetics.*

From the moft remote times antimonials were known to poffefs an emetic quality: this

this property they exert only when diſſolved; but in general they can undergo ſolution within the body as well as without; for, in the primæ viæ, there are ſometimes humours endowed with the property of diſſolving this ſemi-metal, and on this account, antimonials were formerly given in the form of powder. But as it is plainly impoſſible for us to determine *a priori,* either the quantity or quality of this menſtruum, it follows, that from variation in it, either of quantity or quality, the doſe muſt be uncertain, and the effect extremely dubious. Examples are to be met with, of ſome perſons who could ſwallow conſiderable quantities of the regulus, without any inconvenience, which would be highly dangerous to perſons who are ſubject to acidity. At preſent, the mercurius vitæ, the hepar antimonii, and pulverized glaſs of antimony, are much in uſe, becauſe theſe ſubſtances contain the regulus, reduced by ſolution to a ſaline nature; they therefore may be given with much more ſafety, and, being always the ſame, act more powerfully and certainly. Tartar has been almoſt always in uſe, as a ſolvent for this metal, and the ſalt ariſing from this compoſition has been called tartar emetic (¹), from its operation; and ſtibiated

(¹) Mynſicht firſt introduced this preparation in 1631. He employed the crocus metallorum; Zwelfer, the glaſs of antimony; and Lemery the hepar.

tartar,

tartar, from its compofition. I prefer, how-
ever, the name of antimoniated tartar, as
antimony is, at prefent, a more popular
name for this mineral than ftibium : and
this preparation of antimony I defign to ex-
amine in the following pages.

§ III. *Different Methods of Preparation.*

Upon turning over the moft celebrated
difpenfatories, we find a wonderful dif-
ference in the methods of preparing this falt;
all, except the old difpenfatory of Stock-
holm, which mixes with it a lixivious falt,
prefcribe the cryftals or cream of tartar as
the menftruum ; but differ with refpect to
the matter to be diffolved.

The crocus metallorum is directed by the
new Vienna difpenfatory (*a*), by the new
Utrecht (*b*), the Wirtemburg (*c*), the
Edinburgh (*d*), Bornsfo Brandenburg (*e*),
the London (*f*), and fome others ; but the
Edinburgh and the Brandenburg admit the
ufe of the glafs of antimony, which is the
bafis employed by the old Stockholm (*g*)
and the Ratifbon (*h*) ; but the Paris difpen-
fatory (*i*) orders it with an equal part of the
hepar, not freed from the fcoriæ. The
Pharm. Bateana (*k*) employs the flowers of

(*a*) An. Dom. 1734.
(*d*) 1756.   (*e*) 1758.   (*b*) 1749.   (*c*) 1750.
(*h*) 1727.   (*i*) 1738.   (*f*) 1758.   (*g*) 1686.
                              (*k*) 1688.

antimony.

antimony. As to the proportions, the Ra-
tifbon, Vienna, Utrecht, Wirtemburg, Lon-
don, and Brandenburg, employ an equal
weight (*l*) of tartar and of the metallic mat-
ter: the Edinburgh and Paris double that
quantity: there is alfo a difference with re-
fpect to the quantity of water. In the Vien-
na and Edinburgh difpenfatories, 12 parts of
water are ordered to one of tartar; 6 in the
Wirtemburg; and in the reft fo much as
is fufficient for folution. The mixture,
being digefted for a day or two, is boiled
until the tartar is completely diffolved, ac-
cording to the inftructions of the Branden-
burg difpenfatory, and moft others: but
the Paris directs, in exprefs words, 12 hours,
the Edinburgh 10, and the London half an
hour. After filtration, the Ratifbon and
London require cryftallization; the reft eva-
poration to drynefs. In the old Stockholm
difpenfatory, one ounce of glafs of antimony
is deflagrated with two drachms of crude ni-
tre; one drachm of alkali of tartar, and nine
ounces of pure water, are then added; the
whole is boiled to drynefs in an iron pot,
the mafs reduced to powder; warm water is
poured on; it is filtered; and, being evapo-
rated to drynefs, is ftrongly heated on an
unburned brick.

The above will be fufficient to fhew the
difagreement of the difpenfatories: indeed to
compare the differences minutely, would

(*l*) Vid. Difpenf.

exceed

exceed the bounds of fuch a Treatife as this.
We may, however, obferve another method
formerly in ufe, for the purpofe of exciting
vomiting, which is in itfelf fufficiently
commodious, if it were fufficiently exact :
—wine was fet to ftand for a night, in a cup
made of regulus of antimony and tin ; or
elfe balls of this metal, which were called
perpetual pills, were fteeped in wine for a
certain number of hours.   What judgment
is to be formed of thefe contrivances, the
following experiments will fhew : when we
confider the difagreements above-mention-
ed, and others that might be adduced, we
fhall ceafe to wonder at the uncertain effect
of emetic tartar.

Upon accurate examination, we fhall fee
that the weaker of thefe preparations con-
tains fcarcely five hundredths of the metal,
while the ftronger have upwards of 0,24.
Hence, then, appears the neceffity of de-
termining the bafis and the menftruum, in
fuch a manner, by accurate experiment, that
this medicine may always poffefs the fame
properties, and the fame degree of ftrength.

§ IV.   *The Bafe to be chofen.*

The hepar, the crocus metallorum, and
the glafs of antimony, are the fubftances ge-
nerally made ufe of as the bafis of tartar
emetic.   We muft firft enquire whether
thefe three, prepared according to the ufual
formula, actually contain the fame quantity

5   of

of phlogiston; for, according to the varia-
tion of that principle, a greater or fmaller
portion of the metallic regulus will be dif-
folved in the fame quantity of menftruum;
and of courfe the emetic power will vary.
That hepar which is prepared with a larger
proportion of nitre, neceffarily lofes more
of its phlogifton than that in the prepara-
tion of which lefs nitre has been employed;
and, even although an equal quantity of ni-
tre and antimony be (as is ufually the cafe)
employed for this purpofe, it ftill depends
upon other circumftances, whether the re-
guline part be acted upon at all, and in
what degree. The deflagration is perform-
ed either by throwing the nitre and anti-
mony into a hot crucible, or by fetting
fire to the mixture in a cold mortar : in the
former cafe the fulphur is more quickly
deftroyed, and flies off, fo that the metal is
of courfe more completely deprived of its
phlogifton, than in the latter, where no
fufion takes place, and there is no external
operation of fire : hence the hepar made in
the latter way is red; that produced by the
former method rather yellow. But though
the procefs were univerfally conducted in a
crucible, it is impoffible at all times to ap-
ply the very fame degree of fire, nor can
the difference of degrees be poffibly afcer-
tained: fo that, from this circumftance alone,
the products muft differ effentially; add to
which, that the nitre and crude antimony,

D d   cannot

cannot be mixed together fo evenly but that in one part the nitre will prevail, in another the antimony ; and hence, alfo, a variation in the product muft neceffarily take place ; —and the natural confequence of this variation is, that the regulus is fcarce ever acted upon twice in exactly the fame manner.

All the above-mentioned differences arifing in the preparation of hepar, affect in the very fame manner the production of the crocus metallorum ; the latter being no other than the refiduum of the former, infoluble in water : befides another variation in this preparation may arife from the difference of accuracy in wafhing ; for on this account more or lefs remains, which, by encreafing the weight, and abforbing the acid, not only weakens the ftrength of the menftruum, but prevents the fame weight of it from containing always the fame quantity of antimony.

Glafs of antimony is obtained from the fufed calx of this metal : now as the regulus, the crude antimony, and other preparations, may each be calcined by means of fire ; and as all thefe, according to circumftances, and the nature of the preparation, lofe phlogifton in different degrees, it follows inevitably, that the glaffes, made of the calx, muft differ much from each other.

But, fuppofe the crude antimony always ufed for this purpofe, as many direct it to be, yet even in this cafe we cannot be fure

that

that the fame force of fire has been em-
ployed; and as that varies, the calx may
fometimes be fo far deprived of phlogif-
ton, as to be vitrified with great difficulty,
and fometimes retain fo large a portion of
the inflammable principle as to refemble
the hepar in fufion, rather than the glafs;
and between thefe two extremes there are
innumerable intermediate degrees. When
we confider every thing attentively, we fhall
ceafe to wonder at the different degrees of
tranfparency, and the different colours of
the glafs.

Hence we may conclude, that neither
the hepar, the crocus, nor the glafs, can
fupply a bafe for emetic tartar, which will
be always fimilar to itfelf; and therefore,
that they are to be avoided, if a more proper
fubftance can be found.

It may, perhaps, be thought that the re-
gulus is preferable to thofe fubftances which
are moft in ufe: but even if we were in
poffeffion of a fure method of regulating the
fire in the preparation of the regulus, fo that
it fhall always be of the fame nature; and
although we alfo had a fure and commodious
method of meafuring the folvent power of
the menftruum, yet it remains to be deter-
mined by experiment, whether antimony,
in its reguline ftate, can communicate an
emetic quality to acid liquors.

Boiling vinegar indeed attacks it; but
for the acid of tartar, fee § vi. A. vii. A.
Many perfons extol the virtues of wine

D d 2   which

which has lain in a cup of the regulus, and had the powdered regulus fteeped in it for 24 hours; but in this inftance an error may readily conceal the truth: for minute particles of the powdered regulus may, on account of its micaceous texture, be eafily fufpended in the liquor, and therefore may be fometimes fwallowed: befides the regulus when, either by means of too much fire, it is externally deprived of a portion of its phlogifton, or mixed, either internally or externally, with an hepar, it may communicate to wine an emetic quality, although the reguline part itfelf contributes nothing to it. In order to obtain a decifive conclufion, the regulus fhould be often well fufed with a fixed alkali, and then well wafhed with vinegar; befides, the wine which is decanted off fhould be filtered through paper;—this I never had an opportunity of trying more than twice. I fteeped the regulus, eliquated according to the London difpenfatory, divided into fmall pieces, and well wafhed in Rhenifh wine, and kept the bottle clofed in a moderate heat for fix days: the wine, after filtration, did not fhew the flighteft token of an emetic virtue.

Of all the antimonials none deferve fo much attention as the powder of Algaroth, which was fome time fince thought well adapted to this purpofe (¹).—The following experiments will ferve to fhew its nature

(¹) By Macquer.

more completely. It is obvious that if 3 parts of crude antimony, and 4 of corrofive fublimate, be mixed together, by means of heat, and a double elective attraction, a double exchange will take place; for in the corrofive fublimate there is calcined mercury, and in the crude antimony the regulus combined with fulphur : during the operation the antimony yields its phlogifton to the calcined mercury, which thereby becomes quick-filver, and in its turn yields its marine acid to the antimonial calx. This compound paffes over into the recipient, under the name of butter of antimony; and if at length the heat be much increafed, cinnabar is formed, confifting of the fulphur of the crude antimony united with the mercury. We muft take particular notice that neither the regulus of antimony, nor of any other metal, can be taken up by acids, until it is to a certain degree deprived of its phlogifton; and that degree is various in various cafes, as I have elfewhere demonftrated (m).

Butter of antimony, dropped into water, is inftantly decompofed; the water feizes the greater part of the marine acid, and the deferted metal falls to the bottom in the form of a white powder : this powder was formerly known by a number of fingular names, to which it had little claim; but is now generally called powder of Algaroth,

(m) De Attr. Elect.

in

in honour of Vittorio Algarotti, an Italian physician, who has been very lavish in praise of it.

In this operation the antimony is constantly acted upon in the same manner by the marine acid, and consequently always loses an equal quantity of its phlogiston, which is a circumstance very much to our purpose. How well soever this precipitate be washed, though with warm water, yet still a small quantity of the acid adheres, as appears from hence, that upon distillation a small portion of butter of antimony comes over into the recipient; but the acid admixture may be avoided by saturating it gradually with oleum tartari per deliquium; for in this case the more minute and white particles fall to the bottom, which can only be had by washing with an alkali. This is indeed more soluble than the former obtained by water, but supposes a complete decomposition, which yet is not always obtained; at least there is in this case room for fraud, as this method is more expensive and more troublesome.

The precipitate obtained by water, although less in quantity, is yet perfectly soluble, and therefore I prefer it, as being less liable to variation; and we should not, without urgent necessity, confide in the fidelity of the operator.

The argentine flowers are justly enumerated among the best preparations of antimony;

mony; but the preparation of thefe, although more difficult, yet forms a lefs certain bafe for emetic tartar than the powder of Algaroth does.

§ v. *The proper Menftruum.*

From the time that this medicine firft became known, to the prefent day, tartar has been almoft every where, and at all times, ufed for the menftruum ([2]); however, as this falt is not a pure acid, but, as chymical analyfis and fynthefis fhew, a fort of tartarized tartar, with a determinate fuperabundance of acid, it is to be confidered that we are not yet certain whether the fuperabundant acid alone acts, or whether the other ingredients contribute any thing.—I am now to relate the experiments which I made to determine that point.

§ vi. *Power of the Acid of Tartar.*

The firft trials were made with pure acid ([3]) of tartar, of which the fpecific gravity was to that of diftilled water, as 1,230 to 1000.

(A) The following experiments were made with regulus of antimony, prepared according to the London difpenfatory, and reduced to a very fubtile powder. One part of this was boiled for twenty minutes in a phial, with 25 of the above-mentioned acid,

([2]) The old Stockholm Pharmacopœia, after Zwelfer, ufes alkali.
([3]) Retz has defcribed, in the Stock. Tranf. the method of obtaining the pure acid of tartar.

then

then filtered, and fet in a cold place; it was afterwards further evaporated, when a falt concreted in the form of crufts and furrow-ed pieces, which in the fire exhibited the fame properties as cryftallized tartar, with-out any vifible antimonial fmoke. For the better underftanding of this, we muft ex-plain the peculiarities of this acid when ex-pofed to fire upon charcoal, by means of the blow-pipe.

The cryftals of this acid, which are form-ed by flow evaporation, refemble thin tranf-parent lamellæ, irregularly fituated in a way which is called cellular by mineralo-gifts. As foon as the external fluctuating part of the flame reaches the cryftals, they immediately liquefy, and form a mafs pellu-cid like water; this, when expofed to the blue conical nucleus of the flame, foams with a loud noife; and after the expulfion of the water grows black, fends forth firft a fmoke, then a blue flame, and leaves a quantity of fpongy fcoriæ; which diminifh-ing more and more by the extremity of heat, at length become entirely white: this refiduum eafily diffolves in acids, and changes the blue juices of vegetables green, in the fame manner as alkalis do; and this is alfo the cafe with thofe parts which have not been tried upon the cod. From an atten-tive confideration of thefe circumftances it appears that this acid has but little effect upon the metal in its reguline ftate; and the powder collected upon the filter, not being

diminifhed

diminifhed in weight, confirms this opinion.

(B) Hepar of antimony, prepared with an equal quantity of nitre, was put to the proof with the fame quantity of acid, and in the fame manner, except that it was only boiled fifteen minutes ; but the refiduum was the very fame with that defcribed in the laft experiment, both with refpect to cryftallization and habit with regard to fire, with this fingle difference, that the refiduum on the coal is of a reddifh brown.

(c) One part of crocus metallorum was boiled in fix of the acid, diluted with water, for the purpofe of evaporation ; this, when filtered, after 14 days depofited a faline radiated mafs, which gave out fomewhat of an antimonial fume, when expofed to the blow-pipe.

(D) One part of glafs of antimony boiled for 30 minutes with 25 parts of acid, filtered and evaporated, feparated, on the furface of the liquor in the veffel, fmall cryftalline grains ; but all the reft grew gradually hard, and formed a gelatinous mafs much refembling cherry-tree gum.

This, when expofed to the fire, exhibited, befides the phænomena of acid of tartar, not only an intenfe antimonial fmoke, but feveral metallic grains. The gelatinous matter, and the cryftalline, poffeffed the fame properties.

(E) One

(E) One part of diaphoretic antimony, boiled 30 minutes with 25 of acid, and treated as the above folutions, yielded at length a white faline matter, which expofed to flame fends forth a little antimonial fume; and the refiduum is of a brownifh colour.

(F) One part of materia perlata, boiled 15 minutes with 30 parts of acid, yielded a faline cruft, which, expofed to heat, produced an antimonial fume, and a yellowifh brown porous fubftance.

(G) One part of powder of Algaroth was boiled 30 minutes with 9 parts of acid, and then filtered.

This folution, in a digefting heat, became all gelatinous; but afterwards, in a cold place, by means of an air fomewhat moift, became elegantly ftreaked by various rays and branches. This gelatinous matter, when expofed to flame, fwells violently, and yields a copious antimonial fume, but no metallic grains.

At another time, one part of the fame powder, precipitated by water, was boiled for an hour with 5 parts of acid; this was diffolved without any refiduum; and, on flow evaporation, yields irregular cryftals.

(H) Although in the foregoing folutions the acid abounded very much, a good deal of the metal remained undiffolved, notwithftanding the boiling : I attempted to faturate the powder of Algaroth ;—for this pur-

pofe

pofe one part of the powder was boiled two hours with three of acid, when there was no longer any refiduum ; notwithftanding which, the folution retained an acid tafte, and changed the blue juices of vegetables to a red.

Thefe experiments fhew plainly that the acid of tartar alone has fcarce any power in diffolving this femi-metal, fo long as this laft poffeffes its full proportion of the inflammable principle ; but that, in proportion as this principle is diminifhed, the metal is more fitted for folution : this, however, is to be underftood within certain limits ; for although diaphoretic antimony, beyond doubt, contains lefs phlogifton than the glafs, yet no confiderable difference takes place between them with refpect to folubility.

§ VII. *Antimonials diffolved by tartarized Tartar.*

Tartarized tartar being a neutral falt, it does not at firft appear probable, that it can poffefs the property of diffolving metals and other fubftances ; yet the following experiments prove that it actually does poffefs fuch a property.

(A) One part of the regulus was boiled 40 minutes with 8 parts of tartarized tartar diffolved in pure water, and after filtration was fet in a cool place ; a congeries of nu-

merous

merous cryftals was foon formed at the bottom; a piece of this, expofed to the fire, fwelled and grew black; its former colour changed to a white; at length the whole mafs was abforbed by the charcoal, in the fame manner as happens to crude tartar; and this occurs without the flighteft veftige of antimony.

(B) One part of liver of antimony, treated in the fame manner with tartarized tartar for 30 minutes, produced the fame phænomena as (A) above.

(C) One part of crocus metallorum boiled two hours with 8 of the fame falt, give tokens of antimony, but very obfcure.

(D) One part of glafs of antimony, boiled 45 minutes with 8 of the falt, feparated, upon evaporation, a fubftance compofed of faline fpiculæ; which, when expofed to flame, fwelled much, and yielded many reguline grains.

(E) Diaphoretic antimony, fubjected in the fame proportions to the experiment for 35 minutes, exhibited, upon cryftallization, the fame phænomena as in (C).

(F) One part of powder of Algaroth, boiled 20 minutes with 5 of the falt, and filtered, yielded cryftals of two different forts, one of which confifted of complete tetraedra, and, expofed to flame, yielded a great number of metallic grains; the other refembled faline fpiculæ, and feemed to be no other than crude tartar; and this being

3   with

with difficulty feparated from the former, fometimes exhibited marks of antimony.

In another experiment, two parts and a half of tartarized tartar were faturated by half an hour's boiling with one of Algaroth, and formed a brownifh red folution, which gave a flight red tinge to tincture of turnfole, and, evaporated to drynefs, exhibited cryftalline grains, amounting to three parts and an half.

Hence it is fufficiently evident, that tartarized tartar can actually diffolve antimony, although that falt had been purpofely prepared in fuch a manner that the alkali fhould prevail, to avoid deception from fuperabundant acid; befides, the extraordinary agreement of this with the acid of tartar appears from hence, that both menftrua act either not at all, or a little, or much, upon the very fame preparations.

§ VIII. *Antimonials diffolved by Cream of Tartar.*

The different ftrength of the tartareous acid, and of tartarized tartar, being examined, we might in fome meafure judge from thence, of the efficacy of tartar which is compofed of thefe two; but any reafoning of that kind, not confirmed by experiment, muft be fallacious.

(A) Two parts of liver of antimony, boiled

with

with one of tartar, after the cryſtals that firſt formed, yielded nothing but an inſipid ſaline gum.

(B) One part of crocus metallorum, boiled with eight of tartar, cemented into a gummy ſubſtance of a browniſh yellow colour.

(c) One part of glaſs of antimony requires at leaſt three of tartar; if it then be diſſolved by boiling, it will yield cryſtals.

(D) Three parts of diaphoretic antimony, made of regulus, united by boiling with two parts of tartar, on evaporation yielded at firſt ſome cryſtals, the reſiduum was a gum, which, when well dried, did not attract moiſture.

(E) Tartar ſcarcely acts upon materia perlata.

(F) Two parts of Algaroth's powder obtained by water require ſeventy of tartar; if there be more of the menſtruum, and the proper quantity of water, diſſipated by evaporation, the ſuperabundant tartar concretes, containing no more antimony than that which is held by the water of the cryſtals: this combination reddens turnſole; on evaporation it firſt depoſits cryſtals, and then exhibits a clear jelly; a large quantity of water gradually decompoſes it by ſeparating the antimonial calx.

(G) Two parts of the argentine flowers, boiled with one of tartar, yield cryſtals, but no gum: the cryſtals amount to about one-fifth of the weight of the antimony.

2

(H) Bezoar

(H) Bezoar mineral is not diffolved; but antimony, diffolved in a proper aqua regia, and precipitated by fixed alkali, is readily acted upon, and forms cryftals.

In general, to expedite the folution of antimonials, we may ufe partly a fixed alkali, and partly borax.

Argentine flowers fufed with one half of mineral alkali, run together into a yellow mafs, covered with a green cruft : three parts of this, reduced to powder, are diffolved by one of tartar, and the whole mafs becomes gummy.

If one part of tartar be added to one half of fedative falt, three parts of this combination take up one of glafs of antimony, and form a gum, which, being carefully dried, fplits into a yellow powder, which is faid to excel common emetic tartar, both in virtue and folubility : but tartar is not by this artifice rendered more capable of diffolving either regulus, crude antimony, or argentine flowers, than the tartar alone is.

Borax firft calcined, and melted with an equal quantity of crocus metallorum, forms a mafs of an hepatic colour, five parts of which, mixed with eight of tartar, diffolved in water, inftantly generate a colour like that of kermes mineral, and leave no more than two parts undiffolved, which alfo refemble the kermes : by evaporation we get a red gummy falt.

Tartarized

Tartarized borax attacks crude antimony, forming a tranfparent gummy falt of an amber colour, one part of which unites with eight parts of tartar, and holds them dif-folved.

§ IX. *Preparation of an antimonial Emetic, which may be depended upon.*

The foregoing experiments furnifh us with two methods of preparing an emetic of determined efficacy.

Let powder of Algaroth be ufed as the bafis, as it always contains an equal quantity of phlogifton, which is of great confequence (§ v.) ; and let that feparated by water be chofen, as it is more certain than that which is obtained by means of alkali (§ IV.) The prefence of marine acid is of no confe-quence, provided the quantity be always the fame ;—and let the menftruum be either cream of tartar or tartarized tartar : either of the falts, thus prepared, will afford an antimonial medicine for the fhops, of a con-ftant and determined degree of efficacy ; but as they differ in their own nature, and in the quantity of matter which they take up, their effects muft differ, at leaft in degree. I here only mean to inveftigate the method of preparing medicines which fhall always poffefs the fame degree of power; and this end is obtained by both thefe operations. It belongs to the practitioner to determine the ufe of thefe, and to difcover whether

there

there be fo great a difference between them, that it is neceffary to be provided with both; or whether one of them may not anfwer the purpofe, by varying the dofe. In the mean time, I fubjoin the method of properly preparing the two; and firft of

Antimoniated tartar:—let five ounces of cream of tartar, reduced to powder, and two drachms and an half of powder of Algaroth, precipitated by warm water, wafhed, and dried, be gently boiled in a glafs veffel for half an hour, in half a kanne of water; this being done, there generally remains a fmall quantity of a blackifh mercurial powder. I do not faturate the tartar completely, as, in that cafe, fome of the folution turns to a gelatinous matter, and the falt refulting, being long fufpended in the water, is more eafily decompofed, which occafions confiderable inconvenience in practice (§ VIII. F): befides, the weight of a weaker medicine being greater, its quantity may be afcertained with more accuracy; and it may be taken at different times, without any danger: let the filtered folution be evaporated in an open veffel (not metallic) till a pellicle appears; let it then be kept in a digefting heat till cryftals form, which muft be taken away by degrees, and dried on moiftened bibulous paper;—all the clear cryftals are equal in weight to the tartar employed: the more purely faline crufts adhering to the fides of the veffel, amounting to about half an ounce,

E e   are

are to be well wafhed off with cold water, and kept by themfelves—the laft red and thick lixivium muft be thrown away.

Tartarized tartar antimoniated : — let ten ounces of tartarized tartar, and three drachms of Algaroth's powder, prepared as in the laft procefs, be boiled in a glafs veffel for half an hour, with one-fourth of a kanne of water : let the folution be filtered, evaporate the brownifh red lixivium till a pellicle appears, expofe it then to a digefting heat, and cryftals will feparate by degrees ; thefe muft be dried upon wet bibulous paper :— when collected they only equal half the weight of the menftruum ; the faline crufts, which may be purified by wafhing, fcarcely exceed one-tenth of the tartarized tartar —the reft, together with the dark red lixivium, fhould be thrown away.

§ x. *Properties of antimoniated Tartar.*

The emetic falt, prepared after the manner now defcribed (unlefs the natural coalefcence of the particles be fomehow interrupted) is of an octaedral figure, the pyramids fomewhat more elongated than thofe of alum ; the cryftals are colourlefs as water, and either wholly, or for the moft part, tranfparent : the antimony conftitutes about a third of their weight ; they neither crack in the air, nor attract moifture ; but, when old, affume an opake whitenefs : expofed to

3   flame

flame with the blow-pipe, they decrepitate, burn, emit an antimonial fume, and leave upon the coal some metallic grains.

In a moderate heat (15°) distilled water dissolves about $\frac{1}{80}$ its own weight, or nearly three grains, in half an ounce; and that without any alteration, either in colour or clearness. Tincture of turnsole is scarcely reddened by the solution; alkalis, whether fixed or volatile, caustic or mild, precipitate it; the subtile snowy powder which separates adheres very strongly to the glass vessels in which the operation is performed.

In the first lixivium (§ ix.) a remarkable difference is observed with respect to this precipitant: for if it be entirely pure or caustic, a white, subtile, and very spongy powder is separated, which subsiding, remains unchanged; but if the alkali be mild, after a few hours the precipitate begins to concrete in the form of radii diverging from different points, resembling those figures by which sculptors imitate the sun : but if the solution containing those radiating masses be exposed to an heat of 30°, within a quarter of an hour the figures disappear, and nothing remains but a shapeless powder.

That which is precipitated by common fixed alkali after washing, being exposed to flame, betrays scarcely any antimony : it leaves a white spongy mass which is totally soluble in marine acid, but is so far from

being

being diffolved by vitriolic acid, that, by that acid, it is precipitated from the marine.

A like precipitate is obtained by means of common volatile alkali: but that which is obtained by cauftic volatile alkali does not exhibit thefe figures; gives out fcarce any fmoke when expofed to flame; and forms an afh-coloured, fufible, but fixed glafs: lime-water alfo precipitates it, but the precipitate is again diffolved, upon agitation, unlefs a fufficient quantity of lime-water had been added at firft;—in this precipitation too the figures appear.

By concentrated vitriolic acid a large quantity of white matter is thrown down, which again difappears on agitation; if collected, wafhed, and expofed to flame, it firft grows brown, and concretes into little maffes, which afterwards give out an antimonial fume, and are confumed.

Hepar fulphuris, dropped into the faline folution, produces a fulphur auratum.

The reddifh yellow colour of this lixivium depends upon iron, as is eafily fhewn by phlogifticated alkali, which immediately generates Pruffian blue.

§ XI. *Properties of tartarized Tartar antimoniated.*

Tartarized tartar, ftibiated, forms rarely tetraedral, but generally octaedral cryftals, if

suffered

suffered to crystallize freely; of these some
are pellucid, and void of all colour, others
have a little opake whitenefs; the habits of
the cryftals, both in the air and fire, are the
fame with those of the antimoniated tar-
tar : the metal forms about one-fifth of their
weight. Diftilled water, in a moderate
heat, takes up nearly $\frac{1}{48}$ its own weight,
that is five grains in half an ounce, and
ftill retains its colour and clearnefs; it fhews
fome faint figns of a fuperabundant acid; the
alkalis and vitriolic acid produce the fame
phænomena, as we defcribed in the former
fection; with this difference, that they are
produced more fparingly and flowly, and
that the figures there mentioned do not in
this cafe occur.

The folution of the firft boiling is of a
brownifh red, and the magiftral lixivium
ftill more fo : for experiment fake a little
diftilled pure vinegar was poured in, and
afterwards a fingle drop of a phlogifticated
lixivium, and in an inftant the blue colour
appeared : the iron then, in this cafe, is
prefent without an acid; for, to decompofe
the phlogifticated alkali, a double elective
attraction is required. Many of the laft
lixivia, which are red, and do not readily
form cryftals, doubtlefs owe their proper-
ties to dephlogifticated iron.

Whence, in the prefent cafe, this metal
can come, is not at prefent very clear :

the

the aſhes are indeed boiled to dryneſs in an iron pot, but the cream of tartar is purified in braſs veſſels ; beſides, the white alkali of tartar, when boiled in a glaſs veſ-fel with powder of Algaroth, gave alſo a browniſh red-coloured tinge.

DISSERTATION XI.

OF

MAGNESIA.

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§ I. *Brief History of Magnesia.*

AT the beginning of the prefent cen-
tury, a certain canon regular fold,
at Rome, a fort of powder, under the title
of magnefia alba, or Count Palma's pow-
der, which he afferted to be a panacea : but
the preparation of it was follicitoufly con-
cealed as a profound fecret, until Mich.
Bernh. Valentini, in the year 1707 (*a*), dif-
clofed the method of preparing it, by cal-
cination, from the laft lixivium of nitre.
Two years after, Joh. Hadr. Slevoght (*b*)
taught another and more eafy method of
procuring it, by precipitation : after this,

(*a*) In a differtation printed at Gieffa. In his *Praxis*
Medica he calls this earth the *laxativum polychreftum.*
(*b*) In a differtation printed at Jena, 1709.

in

in 1717, Lancifi (c) wrote upon this fub-
ject ; as alfo did Fred. Hoffman (d), and
other moderns. From that time the ufe
of this powder has very much increafed, and
it is now introduced into moft difpenfa-
tories.

Many confidered this powder as calca-
reous earth, as they were not acquainted
with any other which effervefced with
acids ; and, above all, becaufe they neglect-
ed all further examination.—However, F.
Hoffman obferved, that it differed from the
earth prepared from crabs eyes, fhells of
oyfters, and eggs, in this particular, that
all thefe, united with vitriolic acid, afford
an infipid falt, whereas magnefia produces
one intenfely bitter. At length the na-
ture and properties of magnefia were com-
pletely elucidated by two of the moft cele-
brated chymifts of the prefent age ; I mean
Dr. Black, of Edinburgh, who publifhed
his experiments in 1755 (e), and the
Principal of the academy at Berlin, A. S.
Margraaf, who publifhed his in 1759, *as
it fhould feem*, entirely ignorant of Dr.
Black's Effays (f). Both thefe gentlemen
have examined the nature of this earth
with the utmoft accuracy and diligence ;

(c) Annot. in Mercati Metalloth.
(d) Obf. Phyfico-chem.
(e) Edinburgh Effays.
(f) Mem. Berlin.

and

and have moſt evidently ſhewn, that it dif-
fers altogether from lime : but, contented
with diſcovering its properties and diſ-
tinguiſhing charaᵭteriſtics, they paſs over its
geneſis, as not being yet aſcertained by un-
doubted experiments. It is certain that the
geneſis and reciprocal tranſmutations of bo-
dies are ſubjeᵭts ſo deep, that nothing con-
cerning them ſhould be determined from a
ſlight ſimilitude, or rude and imperfeᵭt expe-
riments ; theſe being matters which are only
to be eſtabliſhed by the agreement of the
moſt accurate analyſis and ſynthesiſ. If we
were at liberty to adapt obſervations, expe-
riments, and the very nature of things, to
pre-conceived theories, there would ſoon be
an end to all the excellence and certainty of
natural philoſophy, and that ſcience would
be entirely overturned.

I ſhall, for the ſake of conneᵭtion, briefly
relate the diſcoveries of theſe two very ex-
pert chymiſts ; but my chief labour ſhall
be employed concerning thoſe circumſtances
which they have either omitted, or touched
upon but ſlightly.

§ 11. *Preparation of Magneſia.*

This powder may be prepared in many
different ways ; the moſt pure is that pre-
cipitated from Epſom ſalt : ſcarcely more
than half the weight of alkali of tartar is
requiſite ; but as that ſalt is expenſive, pot-

ashes

afhes are generally ufed : however, as thefe
are commonly mixed with vitriolated tartar,
and with filiceous earth, nearly an equal
quantity is neceffary : both the falts fhould
be diffolved in at leaft a double quantity
of pure water ; after filtration they are to
be mixed and boiled, then fet to ftand at
reft, until a powder precipitates ; the clear
water is then poured off, and frefh warm
water added ; this again is to be poured
off, and the operation repeated, until the
precipitate is freed from all the heteroge-
neous matter, which can be wafhed away
by water : finally, the whole refiduum is
to be dried upon a filter or a cloth.

100 parts of Epfom falt produce about
42 of aerated magnefia, but only 25 of mag-
nefia which does not effervefce with acids ;
this difference depends upon the precipi-
tating alkali, as it is faturated with, or
deprived of, aerial acid. In the former
cafe 58 parts of alkali are requifite, in the
latter, about 45 ;—the filtered liquor yields
about 32 of vitriolated vegetable alkali.

The rationale of the operation is this :—
the double portion of water, added to the
two falts to be mixed, is not only fufficient
to diffolve them, but alfo the vitriolated
alkali which is generated by the mixture.
The vitriolic acid of the Epfom falt at-
tacks the alkali, and expels the aerial acid,
if any be prefent, which unites intimate-
ly with the deferted magnefia : but the

boiling

boiling prevents the magnefia from being diffolved in the water, by a fuperabundance of the aerial acid. By calculation, 58 parts of alkali of tartar contain about 13 of aerial acid; 10½ of which are juft fufficient to faturate 19 of pure magnefia; 2½ therefore are left to unite with the water: if this be equal, or fuperior to 1,388 parts (for, in a moderate heat, water can take up at leaft 0,0018 of its own weight) when thus faturated with aerial acid, therefore, it can take up nearly $\frac{1}{5}$ of the precipitate (§ IV.): the menftruum, therefore, which diminifhes the quantity of the mafs required, being volatile, muft be expelled by heat. At firft fight, it cannot but appear very fingular, that fo much alkali is neceffary to effect a complete precipitation; while, at the fame time, not above 30 parts of vitriolated tartar are obtained, which contain at moft but 17 parts of pure alkali: but we muft in general take notice, that, to effect a complete decompofition, the quantity of a precipitant which would be fufficient to faturate the matter in a difengaged ftate, is by no means fufficient; triple, quadruple, nay, fometimes fextuple the quantity, being neceffary: befides, the alkali which, in this cafe, is fuperabundant, renders the vitriolated tartar more foluble; fo that the whole does not eafily cryftallize.

The laft lixivia of nitre, and of common falt, which refufe to cryftallize, contain
                                        magnefia,

magnefia, diffolved in nitrous or marine acid ; and the magnefia is collected by precipitation, evaporation to drynefs, and calcination : if it is obtained from nitrous acid it is called magnefia of nitre, to which the name of pulvis fentinelli was formerly given ;—that which is got from marine acid is called magnefia of common falt : the former always abounds in heterogeneous matter, particularly with lime ; hence the nitrous lixivium yields more than four times the weight of powder which is obtained from the marine lixivium (g). The magnefia obtained by precipitation is very different from that obtained by calcination ; as this latter can fcarcely be entirely freed from marine acid, and befides we fhall fee hereafter the effect of the fire (§ 111).

§ 111. *Pure Magnefia.*

Common magnefia, after having been expofed to a white heat, does not effervefce with any acid : the aerial acid being ex-

(g) 1 lb. of a nitrous ley affords, according to Spielman, 4 oz. of magnefia, by calcination, and 5 by precipitation. Margraaf, out of 1 lb. of marine ley, obtained 1 oz. 1½ drachm, and 10 grains, by alkali of tartar, and by volatile alkali 1 oz. : when volatile alkali is ufed, a falt, confifting of three ingredients, is found in the liquor ; *viz.* of magnefia, volatile alkali, and vitriolic acid, which cannot be feparated by cryftallization.—Hoffman, in the laft ley of the falt-works at Hall, found magnefia.

expelled

expelled by the fire. If the operation be properly conducted, 100 parts of magnesia will lose 55 of their weight; this loss is occasioned by the expulsion both of the water and the aerial acid. If the heat be violent, and long continued, a greater loss of weight is found to take place, as the violence of the fire is capable of dissipating some even of the fixed parts.

After proper calcination, I call the magnesia pure, because it is freed from water and aerial acid : but it can scarcely be obtained perfectly pure, except by means of the volatile alkali : for the fixed alkalis, when used as precipitants, adulterate the magnesia, frequently with lime, but always with siliceous earth ; with which the alkali of tartar is found loaded, unless when crystallized : the mineral alkali, when properly reduced to crystals, is likewise free from siliceous earth. Calcined magnesia dissolves in all the acids but flowly, and without effervescence ; and in this state requires about the same quantity of acid to saturate it as before the calcination ; and forms, with the acids, the very same middle salts : it does not grow sensibly warm with water, nor does it dissolve in it like lime ; it is therefore a true earth, so far as can be collected from experiments hitherto made.

100 Parts of pure magnesia, steeped in water, after drying are found to have increased

creafed in weight more than 18 ; whereas
100 of magnefia, faturated with aerial acid,
take up 66 (§ iv.). The pure magnefia
does not effervefce in acids, but in great
length of time, in the open air, it recovers
this property by attracting aerial acid from
the atmofphere : why it diffolves fo very
flowly in acids we fhall fee in § xix.

Pure magnefia cannot deprive any alkali,
except the volatile, of its aerial acid, as acids
have a ftronger affinity to them than to
magnefia. It does not precipitate lime-wa-
ter, but it precipitates all metals, not ex-
cepting platina, from their folution in acids
with it : nitrated filver yields a black pre-
cipitate, and corrofive fublimate one ob-
fcurely red. It alfo decompofes ammoniacal
falts, but flowly ; fo that at firft there is
fcarce any perceptible odour ; but if the
mixture be fufficiently moiftened, and kept
24 hours in a clofe corked bottle, when the
bottle is opened the volatile alkaline fmell
will be obferved very unequivocally.

Magnefia expofed for a long time to a
very intenfe heat, begins to coalefce, and
fhew figns of fufion, particularly the mag-
nefia which is obtained from the lixivia by
calcination. It flows eafily with borax, or
with the microcofmic falts : with equal
parts of flint and borax it affumes the form
of a beautiful glafs, like the topaz : with
equal parts of flint and mineral fluor, a glafs
is produced of the colour of the-chryfolite
fufed :

fufed: with an equal weight of fluor mineral, it penetrates and diffolves the crucible.

Magnefia, mixed almoft in any proportion with lime, pure clay, and flint, flows in the fire; and, with a quadruple proportion of green glafs, forms a mafs like porcelain, which gives fire with fteel.——Even an equal weight of flint, of quick lime, of terra ponderofa, of glafs, of lead, of alkali of tartar, and finally of vitriolated tartar, will not flow alone with magnefia; but common clay runs with it into an hard mafs.

Glafs cemented in magnefia refembles porcelain (*h*).

§ iv. *Aerated Magnefia.*

That magnefia which is faturated with aerial acid I call aerated magnefia, becaufe it contains that acid which abounds in the atmofpheric air: fuch is that which is precipitated by a cryftallized fixed alkali (§ 11.); this effervefces in acids, and by a

(*h*) M. Morveau here relates an experiment, in which he expofed magnefia, and at the fame time calcareous earth, to a violent heat: the former fhewed no figns of fufion, nor did it even adhere to the crucible; the calcareous earth was fufed along with part of the bottom of the crucible. He had before afferted that magnefia was one of the moft fufible earths *per fe*, and promoted very much the fufion of other earths;—an opinion he now retracts. Macquer and d'Arcet had before fhewn the refractorinefs of this earth. B.

flow

flow faturation lofes 0,25 of its weight; the fubftance, of which the expulfion occafions this lofs, being collected by a proper apparatus, and examined, is found to poffefs all the qualities of aerial acid. Hence it follows, that 100 parts of aerated magnefia contain 25 of that acid, 30 of water, and 45 of an earthy matter diftinct from all others hitherto known (§ 111. and xix). Magnefia, fully aerated, contains 30 lb in 100 of aerial acid: it is therefore in reality a medial earthy falt, of which (when completely cryftallized) a kanne of diftilled water, in a moderate heat, takes up 47 grains. Water faturated with aerial acid diffolves a far greater quantity, even fo far as an ounce and a quarter; provided the water, loaded with abundance of the acid, meets the magnefia minutely divided, as in the moment of precipitation, as it is in that ftate more expofed to the action of the furrounding menftruum. A folution of this fort in the open air is gradually deprived of its fuperabundant acid, which flies off, and thence a portion of magnefia, which had been diffolved, muft feparate; this takes place firft upon the furface, as it is there the volatile menftruum firft begins to be deficient. The pellicle which is formed, on examination is found to poffefs the properties not of lime, but of magnefia.

Evaporation being conducted leifurely, cryftals alfo appear, partly confifting of pel-

lucid

lucid grains, partly of fafciculi of rays di-
verging from the fame point (*i*). Diftilled
water, aerated, and faturated with magnefia,
exhibits the following properties with pre-
cipitants.

(A) It makes paper weakly tinged with
turnfole more diftinctly blue ; paper ftained
red by Brazil wood it makes blue ; and
induces a light brown upon the yellow of
turmeric : fo that at firft we fhould afcribe
thefe changes to an alkaline mixture, which
adhered in the precipitation, and had eluded
the wafhing ; but this fufpicion foon falls
to the ground, if we employ magnefia preci-
pitated with volatile alkali, as this alkali
produces the fame changes of colour ; but
we muft obferve thefe changes quickly dif-
appear, together with the volatile fubftance
which has occafioned them ; whereas thofe
made by magnefia, although precipitated by
this alkali, are permanent ; they therefore
depend upon the earth alone.

(B) Upon the addition of acids, innume-
rable bubbles, extremely thin, float on the
furface ; thefe are occafioned by the aerial
expelled by the ftronger acids.

(C) Aerated fixed alkali occafions no
change, unlefs the quantity of water be in-
fufficient for diffolving the magnefia and the
alkali both together ; in which cafe the
former is feparated : but if a pure cauftic

(*i*) Tab. I. fig. 8.

F f

alkali

alkali be employed in proper quantity, the earth is immediately precipitated pure, *i. e.* incapable of effervefcing with acids (§ 111). Thefe alkalis are therefore capable of feparating aerial acid from magnefia.

Lime (which in its peculiar properties bears fome analogy to fixed alkalis) in this cafe has the very fame effects as fixed alkali; when faturated with aerial acid it occafions no change, but lime-water or quick lime precipitates the magnefia pure.

The aerial acid adheres more readily to magnefia than to the volatile alkali; for if the former, when cauftic, be added to the latter, and kept in a clofe veffel for fome days, at length the alkali is found cauftic, and the magnefia will effervefce with acids. Another experiment feems indeed to overturn this; for magnefia diffolved in water by means of aerial acid, is precipitated by pure volatile alkali: but it is to be obferved, that here the precipitate effervefces with acids, fo that the alkali has taken away none but the fuperabundant aerial acid; and the portion of magnefia, which was only held diffolved by the fuperabundance, neceffarily falls to the bottom.

(D) All the middle falts, whether earthy or metallic, are precipitated by aerated magnefia, and that by means of a double elective attraction, as pure magnefia has not that effect. By this method lime and terra ponderofa, diffolved in other acids, are thrown down;

down; for while their menftrua feize the magnefia they themfelves fall to the bottom, united with the aerial acid, as appears from the increafe of their weight, and their property of effervefcing with acids.

The precipitates occafioned by pure magnefia gain no increafe of weight, and, if they be metallic, affume colours different from thofe of the precipitates occafioned by aerated magnefia : the latter feparates corrofive fublimate of a darker colour, but after a few hours the colour of both precipitates is a reddifh afh-colour.

If to aerated magnefia, diffolved in water, be added a folution of corrofive fublimate, the mixture grows a little milky, and by degrees depofits a quantity of white fediment; then by little and little, firft upon the furface, and afterwards at the bottom, thin blackifh cryftals concrete, compofed of mercurius dulcis, and calx of mercury partly aerated.

The fmalleft drop of folution of mercury in boiling nitrous acid, is inftantly and copioufly thrown down of a brownifh yellow colour, by water loaded with magnefia, by means of aerial acid : but the folution of the fame metal, made in the cold, yields a white powder, which, after a few days, grows greyifh; this happens becaufe the metal has loft little of its phlogifton.

§ v. *Vitriolated Magnesia.*

Vitriolated magnesia is called English salt, Epsom salt, Seydlitz or Seydschutz salt, deriving a name from the place whence it comes; but these all differ very little from each other, except in the proportion of salited magnesia which they contain mixed with them. On account of its taste it is vulgarly called bitter purging salt; but it is with more propriety called, from its nature, vitriolated magnesia, especially when it is free from heterogeneous matters :—in crystallizing it exhibits quadrangular prisms, with pyramidal apices, which are also quadrangular.

This salt is so easily soluble, that a kanne of distilled water, in a moderate heat, can take up 70½ ounces, but by boiling 140, before a pellicle appears; yet this last solution, when exposed to cold, concretes totally.— The bulk of the water is encreased about 0,45, by the addition of the salt, and the heat of boiling; a circumstance which ought to be taken particular notice of in determining the quantity of it; for in general the quantity of water is determined by the measure of the solution, which is always fallacious. If regular crystals are required, the evaporation must only be continued until a drop let fall on a cold surface concretes in a few minutes.

This salt, exposed to a dry air, first loses
its

its tranfparency, and at length falls into a
white powder : by complete calcination all
the water of cryftallization flies away ; this
water forms nearly one half of the whole,
amounting to 0,48 : hence therefore it ap-
pears, that 100 parts contain 19 of pure mag-
nefia, 33 of vitriolic acid, and 48 of water
(§ 111).

Fixed alkali quickly precipitates it, as
well as the volatile alkali when aerated, nay
even that which is commonly confidered as
pure. This laft cafe feems to indicate a
doubt with refpect to the degree of affinity :—
as pure magnefia, added to a folution of that
falt which is called fecret ammoniac, and
kept for fome days in a bottle clofely ftop-
ped, difcovers, upon opening the bottle, a
diftinct odour of volatile alkali : this pre-
cipitation may be attributed to other caufes.
Thus the volatile alkali can fcarcely be pro-
cured perfectly pure, being either adulte-
rated with water or aerial acid : befides, the
pureft, when expofed ever fo little to the
open air, or to air newly expelled from the
lungs, inftantly attracts a portion of that
acid ; and thus, by a double elective attrac-
tion, acquires the property of being decom-
pofed : yet the precipitate occafioned by the
volatile alkali generally exhibits, on folu-
tion, very flight marks of effervefcence :
this the love of truth obliges me to confefs ;
fo that if this precipitation be owing to the
aerial acid, it is evident that a much fmaller

quantity

quantity of it fuffices for this purpofe than for faturation : but thefe caufes are acciden- tal; there is one, however, which is con- ftant, v. g. the volatile alkali is very ftrongly united with magnefia and vitriolic acid; now in this triple falt the acid, formerly entirely attached to the magnefia, muft be divided in a certain ratio between the two; and hence the magnefia, which does not en- ter into this new union, is feparated, and falls to the bottom.

Lime-water feparates magnefia from the vitriolic acid, although crude or aerated lime has no effect; hence it evidently ap- pears how much the efficacy of this fub- ftance is affected merely by an union with aerial acid.

The acid of fugar, added in proper quan- tity, takes away the whole earthy bafis from the vitriolic acid, and precipitates it to the bottom in the form of a white powder, efpe- cially if the folution be infpiffated by gentle evaporation; for otherwife, by means of the fuperabundant acid, the greater part is held fufpended.

In the fame manner the vitriolic (which in power of attraction is among the ftrongeft) yields magnefia to the fluor acid : at firft a very fmall fediment falls, but during eva- poration the fluorated magnefia by degrees appears; in this cafe, however, heat muft be carefully avoided, as by it the more vo- latile of the menftrua are much weakened.

The

The vitriolic acid is alfo expelled by the acid of phofphorus, at leaft when the watery part is fufficiently diminifhed by evaporation; fpirit of wine coagulates the mixture in the fame manner as it does with phofphorated magnefia.

Rectified fpirit of wine does not take up vitriolated magnefia, which may by it, therefore, be feparated from water. In proportion as the folution is more faturated, and the fpirit more pure, the coagulation happens more quickly; fo that in a few minutes the whole mixture will concrete into a folid mafs.

The Seydlitz, Seydfchutz, or Epfom falts (k) are got by evaporation from the water of fountains in the places from whence they borrow their names. Thefe waters contain other fubftances, and from hence, exclufive of the difference in exficcation, the falts vary; hence the Seydlitz falt fcarcely attracts moifture from the air. The Epfom or Englifh falt is prepared from fea-water, after the cryftallizations of the common falt, by boiling, and by adding colcothar of vitriol, which contains a portion of acid; this acid, quitting

(k) The Epfom falt was firft noticed by Grew in 1675; but as only a much fmaller quantity than was ufed could be got from fprings, chymifts anxioufly fought for an artificial mode of compofing it. Hankwitz prepared it at London from common falt, or the laft laft ley of this and calcined vitriol, Eph. N. C. cent. 3 and 4. Others found it in different fprings: Bertrams, in thofe at Creutzburg; Gehrardten in thofe at Oberneufultz, &c.

the

the iron, unites with the magnesia, and pro-
duces a cryftallizable bitter falt. That which
comes to us under the form of cryftalline
aciculæ contains fo much falited magnesia,
either united with the water of cryftalliza-
tion or adhering externally, that it eafily de-
liquefces by the moifture of the air. The
cryftals of this falt are fometimes fo large
that they are fold for Glauber's falt; and
on the other hand, in France, Glauber's
falt, being reduced to fmall fpiculæ, by agi-
tating it during the cryftallization, is fold
for Epfom falt.

Thefe frauds are indeed of little confe-
quence, yet they throw a veil over the truth,
and are not eafily difcovered. Thus, lime-
water does not precipitate genuine Glauber's
falt; but Epfom falt inftantly yields up its acid
to the lime, and a felenites, together with
the deferted magnesia, falls to the bottom.

Vitriolated magnesia does not give up its
acid on diftillation.

Phlogifticated vitriolic acid alfo diffolves
magnesia; but the middle falt, arifing from
this combination, is eafily diftinguifhed from
Epfom falt by its tafte; it alfo yields fmall-
er cryftals, and, upon the addition of any
acid, even vinegar, it gives out a pungent
and fuffocating vapour: it is feparated
from water by fpirit of wine, although, by
the acceffion of phlogifton, it fhould feem to
approach nearer to that inflammable men-
ftruum.

§ VI. *Nitrated*

§ vi. *Nitrated Magnesia.*

The nitrous acid, faturated with magne-
fia, after proper evaporation yields prifma-
tic, quadrangular, fpathous cryftals, without
apices ; thefe poffefs an acrid, and, at the
fame time, an exceeding bitter tafte, and
eafily deliquefce in the air : if paper be
moiftened with a dilute folution of it, after
drying, it burns with a green flame ; which
colour aqua fortis alone, in the fame way,
frequently exhibits.

The acids of fluor, of fugar, of phof-
phorus, and vitriol, take away magnefia
from the nitrous, a circumftance which
yet efcapes obfervation, for thefe new com-
binations are foluble in nitrous acid ; they
may, however, be brought into view either
by evaporation, or by dropping in highly-
rectified fpirit of wine, as this, by abforbing
the water, precipitates the falts.

Nitrated magnefia yields its acid on dif-
tillation ; it diffolves completely in fpirit
of wine : in this cafe, however, its flame is
not green, but becomes larger and more
vivid than before.

Phlogifticated nitrous acid, faturated with
magnefia, betrays itfelf by its tafte, and,
on the addition of any, even the vegetable
acid, by its fmell ; but thefe principles are
fcarcely feparated by the phlogifticated vi-
triolic

triolic acid; at leaft the addition of rectifi-
ed fpirit of wine occafions no coagula-
tion (*l*).

§ VII. *Salited Magnefia.*

Magnefia, diffolved in marine acid, has
an exceeding bitter tafte, and cannot be
cryftallized, unlefs, after being much infpif-
fated by heat, it be expofed fuddenly to ex-
treme cold; but the aciculæ which concrete
upon this occafion foon deliquefce by the
moifture of the atmofphere. While the ma-
rine acid diffolves magnefia, its tranfparency
is fomewhat obfcured; and when the fa-
turation is finifhed, the folution quickly
concretes into a jelly of a watery colour;
which, if diluted while warm, yields fpongy
maffes, not foluble even in marine acid : a
jelly of this fort is produced by the acids
of nitre, of ants, of vinegar, and others, but
does not appear in the filtered folutions;
for the moifture being in a great meafure
diffipated, thefe yield a vifcid matter like
gum, which, when well wafhed, is found to
be filiceous (§ xv.) owing to the impurity of
the precipitating alkali.

(*l*) "Lime-water decompofes nitrated magnefia. In a
memoir on the treatment of the mother-leys of nitre, I
have pointed out this procefs as very advantageous, not
only for completing the analyfis of them, but alfo for
feparating magnefia from calcareous earth, at fmall ex-
pence." Morveau.

If

If aerated magnefia be employed, the ae-
rial acid which is feparated is partly ab-
forbed by the water, which, by this means,
takes up a portion of the magnefia without
any other affiftance : hence, when the fo-
lution is finifhed, it changes vegetable co-
lours like an alkali (§ iv. A) ; which is true
not only of the folution made by marine acid,
but of all others, unlefs the acid folvent be
fuperabundant. If, therefore, an exact fa-
turation be required, it is more eafily had
by pure magnefia ; for if aerated, in order
to anfwer the end, an accuracy extremely
troublefome is requifite ; for either the fu-
perfluous aerial acid muft be expelled, or
the faturation muft be determined by re-
peated trials.

Salited magnefia diffolves in fpirit of wine,
and is fubject to the fame laws of affinity as
the nitrated, except that this is foluble in ni-
trous acid ; for on adding that acid, and eva-
porating, nitrated magnefia is formed ; be-
fides, the acid of ants unites intimately with
falited magnefia, forming a cryftallizable falt
compounded of three ingredients : this com-
bination yields its acid to a diftilling heat.

§ VIII. *Fluorated Magnefia.*

The fluor acid (*m*) at firft violently at-
tacks magnefia ; but as the faturation ap-

(*m*) This acid was defcribed by its experienced in-
ventor, Mr. Scheele, in the Stockholm Tranf. for 1771.

proaches,

proaches, certain particles, almoſt inſoluble, are ſeparated; and at length, when the ſaturation is complete, the water, which hardly diſſolves the fluorated magneſia, lets fall at once all that the ſuperabundant acid had taken up.

That portion which can be diſſolved by means of abundance of acid, on ſpontaneous evaporation concretes above the liquor to the ſides of·the veſſel, in the form of a tranſparent mucilage, marked with long and very ſlender cryſtalline threads; but at the bottom we find ſpathoſe cryſtals, which, though not eaſily diſſolved, are yet not entirely rejected by ſpirit of wine. Their form is hexangular priſms, ending in a low pyramid compoſed of three rhombi.

· Neither vitriolic, nor any other acid, decompoſes fluorated magneſia by the humid way: this combination, when alone, and pure, does not yield its acid in the moſt intenſe heat of diſtillation.

§ IX. *Arſenicated Magneſia.*

· The acid of arſenic (*n*), united to ſaturation with magneſia, is with much difficulty ſoluble in water; and therefore, like the former combination, the whole ſubſides, and is again diſſolved, if ſuperabundance of acid

(*n*) This acid will be ſoon deſcribed by Mr. Scheele, in the Stockholm Tranſ. See Diſſ. XXI. vol. ii.

be added : upon evaporation it then yields
no cryftals, but a vifcid mafs like gum,
which is not precipitated by fpirit of wine;
yet it is worth obferving, that the acid of
arfenic, added to acetated magnefia, which
likewife forms nothing but a vifcid mafs
(§ XIII.) produces elegant prifmatic cryftals,
which may be called folar, as many of
them diverge like rays from a point ; the
reafon is doubtlefs this :—the acid of arfenic,
unlefs when fuperabundant, cannot fufpend
the magnefia, but all fuperfluous acid im-
pedes cryftallization ; now the acetous acid
diffolves the arfenicated magnefia, and fuf-
fers it to concrete into cryftals by a flow
evaporation ; and the fame thing takes place,
if the acetous acid be expelled from the mag-
nefia by the acid of arfenic : thefe cryftals,
in a long continued heat, calcine fo far as to
grow opake and white. What has been now
faid of vinegar holds with refpect to nitrous
acid, marine, and the acid of ants ; by all
which arfenicated magnefia is not decom-
pofed, but diffolved, and yields folar cryf-
tals : this feems to afford a method of cryf-
tallizing falts, which are difficultly foluble
(§ x. xv.) ; *viz.* let the water be fharpened
with fome fuitable acid, which will not al-
ter the falt required (*o*).

The

(*o*) This procefs opens a new field for obfervations ;
it will be ufeful on many occafions : but I doubt whe-
ther

The fluor acid, the acid of fugar, of phofphorus, and vitriol, feparate magnefia from the acid of arfenic ; but the acid of tartar, united with arfenicated magnefia, is generally found to compofe a triple falt.

This falt is not decompofed by fire, unlefs with the addition of phlogifton ; in which cafe the acid intimately united with it generates a regulus.

ther a pure falt can be by thefe means obtained ; the fuppofition appears repugnant to the general and conftant laws of folution ; for a cryftallizing body always, of neceffity, retains a portion of the diffolving fluid ; this, in the falts, is called the water of cryftallization : and if vinegar here performs the office of water, muft not the falt retain the vinegar of cryftallization ? This cafe is different from the precipitation of falts by fpirit of wine, which is only a fudden abforption of the water, and requires that the falt fhould not be foluble in the added liquid : on the contrary, we are forced to admit a real affinity of the fluid with the falt, a gradual approximation not of the falt only, but of the integrant parts of the folution itfelf, in confequence of the evaporation of the fuperabundant portion of the folvent ; it is therefore impoffible that this adhefion of the principles fhould ceafe fuddenly, without any new caufe fupervening ; or that the falt, thus abandoned, fhould affume a regular form. To objeft the uniformity of cryftals produced in this manner in different acids, is in vain : that the two principles conftantly exifting in thefe combinations, fhould, with refpect to cryftallization, be endowed with properties that a third cannot deftroy, is, I think, much more probable ; it is certainly not without example, even in the fimple falts.   Morveau.

§ x. *Boraxated Magnesia.*

The faline fubftance which in borax is
united to the mineral alkali, and is called
the fedative falt by Homberg, fhews, upon
examination, undoubted though weak marks
of an acid nature, it even attacks fome me-
tals, &c.

If magnefia be put into a folution of this,
it will be diffolved, though very flowly, on
account of the weaknefs of the menftruum.
On evaporation irregular cryftalline grains
appear : the principle of connection in thefe
being very weak, they may be feparated in
the humid way by other acids ; even fpirit
of wine feparates them, but takes up a
part of the acid : vinegar and acid of ants
diffolve this falt entirely ; and, when the
moifture is diffipated, it appears in the form
of fpiculæ, on which others ftand at right
angles : it flows in the fire, and that with-
out any decompofition ; nay, the acid of
borax expels from magnefia, by the affift-
ance of heat, all the acids which are vola-
tilized by heat.

§ xi. *Saccharated Magnesia.*

The peculiar acid which refides in fugar
has already been defcribed, together with the
beft method of obtaining it pure : this dif-
folves magnefia, and holds a great quantity
of

of it fufpended, but when faturated it falls to the bottom, refufing to unite with water, which has already been obferved in other inftances (§ VIII. IX.) : it is fcarcely foluble in fpirit of wine.

The fluor acid alone is capable of taking magnefia from acid of fugar by the humid way.

This falt, when ignited, fends forth all its acid, nor does it fhew any veftiges of a coal, as the tartarifated magnefia does, as we fhall fee in the following fection.

§ XII. *Tartarifated Magnefia.*

The genuine (*p*) acid of tartar takes up magnefia in the very fame way as the former acid; and the portion which is fufpended by a fuperabundant acid falls by evapora-tion in polygonal tranfparent grains, re-fembling fhort hexangular prifms truncated at both ends, and more or lefs irregular : fpirit of wine with difficulty attacks this falt; and therefore, when added to a folu-tion of it in water, immediately throws down cryftalline grains.

The acids of fluor, fugar, phofphorus, vitriol, nitre, and falt, decompofe tartarifat-ed magnefia.

This falt readily melts in the fire, boils, fwells, and yields a coal, which, when burn-ed, at length leaves the magnefia free.

(*p*) See the Stockholm Tranf. for 1770.

§ XIII. *Ace-*

§ XIII. *Acetated Magnefia.*

Vinegar, though loaded to faturation with
magnefia, yet diffolves readily in water :
however evaporation be conducted, no cryf-
tals are obtained, but at length a vifcid de-
liquefcent mafs appears, which parts with
the vinegar on diftillation. Spirit of wine
may be completely mixed with this faline
liquor.

All the acids, except phlogifticated vi-
triolic and nitrous acids, and the aerial acid,
decompofe acetated magnefia.

§ XIV. *Formicated Magnefia.*

The acid of ants, when faturated with
magnefia, quits the water, and falls to the
bottom : this is again foluble in fuperabun-
dant acid, and depofits cryftals upon evapo-
ration, which are very difficultly foluble in
water, are void of tafte, do not melt in the
fire, but fwell and decrepitate a little, foon
grow black, and fplit at length into a
white powder, which effervefces with acids ;
becaufe the acid of ants, when it is deftroyed,
yields aerial acid to the magnefia: the figure
of the cryftals is hemifpheric, the cutting
plane being oblique, a little concave, po-
lifhed, with ftriæ (which are fcarce diftin-
guifhable by a glafs) diverging from a center
very like the tubercles of liverwort : hence
the acid of ants is readily diftinguifhed from
vinegar, to which, in other refpects, it is very

G g   like ;

like; it, as well as phlogifticated vitriolic and nitrous acid, takes away magnefia from the acid of ants : one half the weight of this falt is magnefia ; one part of it requires thirteen of water to diffolve it in a moderate heat : fpirit of wine does not take it up (*q*).

§ xv.   *Phofphorated Magnefia.*

The acid of phofphorus takes up magnefia almoft in the fame way as the former; but that which is taken up by a fuperabundant acid, as foon as evaporation begins, yields cryftalline grains, which are fomewhat larger in acetated magnefia when the acid of phofphorus has been previoufly added ; and that for the reafon affigned § ix ; at length, however, the whole liquor falls into a vifcid mafs.

By the humid way the acid of phofphorus takes away magnefia from all the acids, except the fluor acid and acid of fugar—by the dry way all the volatile acids are expelled.

A folution of phofphorated magnefia grows cloudy, upon the addition of fpirit of wine, but when the fpirit is diffipated by evaporation the clouds again difappear.

In general it is proper to obferve, that folutions of common magnefia, in all the

(*q*) If the fmalleft quantity of calcareous earth be mixed with magnefia, fparry cryftals are formed, which efflorefce in the air. See J. Afzelius on the Acid of Ants.

acids,

acids, are of an opal colour, occafioned by filiceous atoms which remain upon the filter ; but, when that operation is neglected, fall by degrees to the bottom, and concrete into a gelatinous mafs (§ III.)

§ XVI. *Whether Magnefia be foluble in alkaline Salts.*

Some bodies are of fuch a nature, that they poffefs an attraction both for acids and alkaline menftrua : among thefe it will be fufficient to mention copper, which is diffolved not only by acids, but by alkali, efpecially the volatile, which forms with this metal a cryftallizable falt ; it has been properly enough doubted whether magnefia was one of this kind of bodies. Margraaf, in the precipitation of magnefia, cautions us againft the ufe of too much alkali, particularly the mineral and volatile, as thefe again diminifh the quantity of precipitate which had been before thrown down : with that noble candour with which this illuftrious man always relates his experiments, he confeffes, at the fame time, that he could not effect a direct folution, although fome bubbles appeared, which feemed to indicate fome kind of action in the menftruum : in this very bufinefs all my labour too was in vain ; but, we now know that the earth, after having been thrown down, may again difappear by another medium ; *viz.* aerial acid (§ II.). To this, therefore, and not to the fole ac-

tion

tion of the alkali, are we to attribute this
phænomenon; especially as the circumstances
attending it agree exactly with the nature
of the alkalis ; for, in the same weight,
volatile alkali contains more aerial acid than
the fixed mineral ; and the vegetable least
of all (*r*).

§ XVII. *Magnesia dissolves Sulphur.*

Magnesia attacks sulphur both by the
dry and the humid way : but the connec-
tion of these substances is so loose, that
they soon separate in the open air.   Let
$\frac{2}{3}$ of a bottle, containing a pound, be filled
with distilled water ; let a handful of mag-
nesia, and as much flower of sulphur, be put
in ; let the air included above the liquor
by rarefied by heat, and the bottle then shut
close ; let it be then kept in balneo mariæ
for some hours; and, after cooling sufficient-
ly, when the orifice is opened, a manifest
hepatic odour strikes the nostrils ; but the
water itself, when filtered, yields, with a
lixivium of fixed alkali, a sediment, which
is soluble in acids.   With solution of silver
it grows black and turbid ; as also with
saccharum saturni : on spontaneous evapora-
tion the bottom of the vessel is, at length,
found covered with a pellicle, intersperfed
with crystalline aciculæ, which dissolve
with effervescence in acids, except a greyish
powder, which, thrown on live coals, gives

(*r*) See Dif. I. § VIII.

out a fulphureous fmell, but no flame; which undoubtedly arifes from hence, that the fulphur is impure, being enveloped with faline particles.

§ XVIII. *Elective Attractions of Magnefia.*

The phænomena above related, point out the following order of elective attractions, in the humid way: *viz.* firft fluor acid (§ x. —xv.); acid of fugar (VIII. XI. XV.); phofphoric acid (XI. XV. V.); vitriolic acid (XV. V. IX.); arfenical acid (IX. V. VI.); nitrous acid (IX. VI. VII.); marine acid (VI. VII. XII.); acid of tartar (VII. XII. X.); acid of ants (X. XIV. XIII.); acetous acid (XIV. XIII. VI.); acid of borax (XII. X. XIV.); phlogifticated vitriolic acid (VI. V.); phlogifticated nitrous acid (XIII. VI. V.); aerial acid (IV.); water (III.); and fulphur (XVII.).

In the dry way the order is different; for in this the more fixed, though weaker acid, by means of the heat, overpowers the volatile, though ftronger. Let M denote any fubftance attracted by two menftrua: the ftronger, in a moderate heat, by the elective attraction A, the weaker by the elective attraction *a*; let us then fuppofe the firft more volatile in the fire, and denote its nifus to rife by v, and the nifus of the other by *v*: it now appears, that M is attracted by a force $= A - a$; but let the heat be continually increafed, and this

force

force will be continually changed. Now, since v increases more than v, at length A — a will be $= v - v$; but when the fire is further increased the equilibrium will be destroyed, and the menstruum, which was before weaker, will prevail : the case will be more simple, if we suppose the weaker menstruum entirely fixed, that is $v = o$. In the Treatise on Elective Attraction, we shall examine more minutely how fire encreases the volatility of bodies.

Hence the acids which are fixed, such as those of phosphorus, arsenic, and borax, are found to prevail over all others ; and from experiments the foregoing table is to be altered in the following manner : *viz.* acid of phosphorus, of arsenic, of borax, vitriolic acid, acid of sugar, nitrous acid, marine acid, acid of fluor, of ants, of vinegar, phlogisticated vitriolic and nitrous acids, and last, aerial acid. The acid of tartar has no place here, as it is destroyed by a sufficient degree of fire.

§ XIX. *Magnesia differs from Lime.*

Magnesia and lime agree in this respect, that they both dissolve in acids, with effervescence ; yet terra ponderosa and aerated alkaline salts possess the very same property, a circumstance which indicates no more than the presence of aerial acid in all of them : but if they are examined more closely, we shall find a remarkable dissimilitude ; the particulars of which we shall

briefly

briefly relate, that the true nature of mag-
nefia may be better and more diftinctly
known.

Water takes up aerated magnefia (not
aerated lime). Magnefia, after a fufficient
calcination, is rendered infoluble (lime, fo-
luble). Pure magnefia makes none but the
volatile alkali . cauftic (lime imparts caufti-
city alfo to fixed alkali). Magnefia, when
faturated with vitriolic acid, conftitutes a
bitter falt, foluble in about an equal weight
of water (lime yields a felenite almoft in-
fipid, one part of which requires more than
400 of water). Magnefia, with nitrous
acid, produces a cryftallizable falt (nitrated
lime can fcarcely be brought to cryftallize).
Magnefia, with marine acid, forms a liquor
which, on diftillation, eafily lofes the
menftruum (lime does not). Magnefia,
with vinegar, refufes to cryftallize (lime
exhibits feveral fingular vegetations). Mag-
nefia is not thrown down from other acids
by vitriolic acid (lime produces gypfum,
which inftantly falls to the bottom). Mag-
nefia attracts the fluor acid, in preference to
all others, then the acid of fugar, and the
reft as above defcribed (lime effects the fame
menftrua in a very different order). There
are many other circumftances already men-
tioned, which, compared with the known
properties of lime, will evidently fhew the
difference.

So great and fo conftant is the difference,
that thefe fubftances ought no more to be

confounded.

confounded. As the magnefia obtained from the nitrous lixivium is almoft always mixed with lime, in accurate examination this impure earth fhould not be employed : whoever wifhes, then, to examine the true nature of magnefia, fhould employ the bafe of the fal amarus, as that, if rightly pre-pared, will never deceive him.

But it has been fuggefted, that magne-fia is lime altered, putting on, *pro re nata*, now the fhape of lime, now entirely put-ting it off; it is fcarcely poffible, that the fame fubftance fhould acquire properties fo different : in the mean time, while we are only fpeaking of poffibility, we can fay no more than that, as yet, chymiftry labours under fo great imperfection, that it cannot, *a priori*, determine whether or not the pow-ers of nature be fufficient to effect fuch a metamorphofis ; but we muft not, from a bare or diftant poffibility, believe the real exiftence of transformation.

The expert are not difturbed by vague affertions. Accurate experiments, both ana-lytic and fynthetic, and thefe accurately employed, at all times and in all places af-ford the fame refults : the vitriolic acid, faturated with lime, produces gypfum ; with magnefia the fal amarus, and that conftant-ly. In order to obtain gypfum from lime-water, we need no other artifice than a perfect faturation : if the acid menftruum is fuperabundant, gypfum is indeed pro-duced, but fo much penetrated by the acid,

as

as to deliquiate in the air, to preferve its polifh long in the fire, and to flow very readily; but if this acid be fuperfluous, or faturated, or feparated by means of fpirit of wine, a true gypfum appears; which will hereafter be feen, when we examine lime. Varieties, occafioned by the abundance or deficiency of a proximate principle, cannot properly be called tranfmutations;—the vitriolic acid remains truly and totally, in itfelf, unchanged; the fame may be faid of lime; although, according to the variety of quantity in each, they may both be varied three different ways: for either they are both faturated, or the acid abounds, or it is deficient; in each of thefe cafes a true gypfum is produced; but in the fecond cafe it is loaded with a difengaged acid; in the third, with a lime not diffolved; and hence its nature and properties muft be more or lefs obfcured: that this is the cafe is evident; and befides thefe two principles may be again feparated in all refpects the fame as they had been before their union; a circumftance which does not agree with a real tranfmutation; at leaft, if the meaning of that word be extended fo far, it will apply to all the neutral and middle falts.

At the time when men were ignorant of the true preparation of Epfom falt, various opinions were entertained upon that fubject; and among others it was thought, that lime, firft diffolved in marine acid, then precipitated by vitriolic acid, filtered, and evaporated

to a pellicle, would yield true Epfom falt.
But whoever tries the experiment will foon
find, that the precipitate firft thrown down,
and the aciculæ after, when wafhed in fpirit
of wine, are no other than perfect gypfum :
this, on account of its being but juft made,
and therefore not yet deprived of the ad-
hering liquor, has a tafte acid, and fome-
what bitter, partly occafioned by the ma-
rine acid ftill difengaged, and partly from
the lime ; but if, by means of filtration
through paper, or, which is better, by fpirit
of wine, it be deprived of its liquor, it
fhews all the properties of genuine gypfum,
unlefs magnefia be mixed with the lime, as
we fhall afterwards fee (§ xx). In this cafe,
therefore, there is no real tranfmutation ;
which, if it took place, would undoubtedly
prevent the production of the fmalleft par-
ticle of vitriolated magnefia.

Nor fhall we fucceed better, if, according
to the directions of others, lime precipitated
from nitrous or marine acid be moiftened, and
afterwards expofed to calcination, with ever
fo great caution : certainly, by this method,
nothing more can be had than lime more
or lefs impregnated with the acid, in pro-
portion as the degree of heat has been lefs
or greater.

Magnefia, precipitated by an alkaline falt
from lixivium of nitre, is readily diffolved
in vitriolic acid, yielding that falt which
goes by the name of Epfom falt ; but that
which is got by evaporation and calcination

<div align="right">neither</div>

neither effervefces, nor feems to be dimi-
nifhed in that menftruum.—Hence magne-
fia is fuppofed to be transformed into lime
by means of fire; but the true reafon of the
phænomenon is very different:—the acid at-
tacks calcined magnefia, indeed, but very
flowly ; for the part of the menftruum
which lies next round it, becoming fpecifi-
cally heavier, finks to the bottom, prevent-
ing the accefs of the difengaged acid ; by
degrees, however, the acid penetrates ; fo
that if a fufficient quantity be added, it will
at length take up the whole of the magne-
fia, which is not the cafe with lime : an
inteftine motion of the liquor accelerates all
folutions ; and hence it is that aerated mag-
nefia quickly vanifhes ; for the aerial acid,
being expelled by the ftronger acid, breaks
forth in innumerable bubbles, which agi-
tate and difplace the feveral particles, fo that
the acid is perpetually in contact with the
magnefia : for the fame reafon calcined
lime and terra ponderofa are diffolved more
flowly than when they are aerated.

Others contend that magnefia is generated
from clay, by means of vitriolic acid ; and
this I will readily grant to be the cafe, pro-
vided any one can fhew a method by which
pure clay can be thus changed;—conjectures
and opinions fhould depend upon or be
formed by experiments. With vitriolic acid
they obtain from common clay the earth of
alum, which being afterwards mechanically
and carefully mixed with filiceous earth,

<div align="right">again</div>

again regenerates common clay (s). From what has been faid it appears, that magnefia is an earth diftinct from all others, whether fimple or compound we will not take upon us to decide; the fame is alfo true of lime : but as in all the experiments hitherto inftituted they preferve conftant properties, and are never decompofed, they ought to be reckoned among the fimple bodies, until a faithful analyfis, confirmed by a proper fynthefis, reveal their origin. That man will certainly deferve well of the fcience of chymiftry who fhall fhew, not by forged opinions, but by undoubted experiments (which, at all times and in all places, will ftand the moft rigorous teft) that magnefia owes its origin to lime or clay.

§ xx. *In what State Magnefia occurs upon the Surface of the Earth.*

Magnefia is lefs common than other primitive earths; or, to fpeak more properly, it is fo mixed with other matters, that it can neither be immediately diftinguifhed, nor often freed from heterogeneous matters, without the help of acid menftrua. Mag-

(s) See Margraaf, vol. ii. p. 49, he concludes " this earth is neither calcareous nor aluminous;"—p. 10 and 11 he fays, " the objections of a certain chymift on this fubject are fo trifling, that to anfwer them would be lofs of time : I fhall only fay, that clay may be recompofed juft the fame as before, by putting together its conftituent parts; wherefore no tranfmutation is produced by the vitriolic acid, nor any new fubftance produced during the operation."

2

nefia, as well as clay, is an exceeding fine
light and fpongy earth, and therefore the
very pureft of them, buried in the earth,
muft neceffarily be foon mixed with hetero-
geneous particles.   Magnefia, lime, terra
ponderofa, clay, and flint, if reduced to a fine
powder, and ground together, along with
water, cannot afterwards be feparated from
each other but by fit menftrua.   It would
however be highly abfurd to deny that thefe
fubftances are contained in their perfect
ftate in the mixture; and to affert, that they
are produced by the action of acids.

All thefe (except the laft, which refufes
to unite with ordinary acids) though dif-
folved and precipitated 30 times, were yet
found abfolutely unchanged: the only variety
which occurred was with refpect to the
three firft, which appeared cauftic or mild,
according as the precipitating alkali had
been either aerated or pure : befides, not
one of thefe five earths could, by means of
any menftruum hitherto tried, be actually
tranfmuted into another; fo that, confiftently
with the rules of right reafoning, we cannot
deny the exiftence of magnefia, although it
is often fo enveloped in heterogeneous matter
that it cannot be extricated without the
help of acid menftrua.   In many bitter
waters we find magnefia combined with vi-
triolic acid ; and the celebrated Monnet has
lately difcovered a fchift which, when roafted
and elixated, yields a true fal amarus, fuch

as

as occurs in our aluminous fchift (*t*), though in fmall quantity.

At the filver mine of Salberg, upon the furface of the great maffes which are annually heaped up for the purpofe of feparating the ore by wafhing, is found a cruft which, when examined, is often found to contain 65 lb. in the cwt. of fal amarus ; for the matrix confifts of calcareous earth, which, befides filiceous atoms, contains magnefia fometimes mixed ; but there are alfo prefent grains of pyrites, which, by fpontaneous calcination, form with the calcareous earth gypfum, and with the magnefia fal amarus.

It is found united with nitrous acid in all nitrous earth, and with marine acid in great quantity in falt fprings, and in the water of the ocean; and it is this which occafions the difagreeable bitter tafte.

It is found in the very fame ftate in which we have it in the fhops, in various mineral waters, as Pyrmont, Spa, and Seltzer, deftitute of every acid except the aerial.—Let me afk, what acid it is that forms it in this cafe; as we fee it can be feparated merely by evaporation ?

Mixed with certain clays, with lime, and filiceous powder, it forms a fingular variety of marl. It is found in the terra lemnia, combined with clay, flint, and martial earth; it alfo enters into the compofition of various ftones ; with flint it is united in the fleatite and ferpentinum; with flint and lime in af-

(*t*) Diff. IX. of the Preparation of Alum.

beftos;

beftos; with flint and clay in mica.—It is alfo hidden in calcareous ftones which have been long buried in the fea, confifting of impalpable particles; and in many others not yet fufficiently examined.

Garnets alone never form entire mountains; yet we cannot from thence doubt of their exiftence.—The fame may be faid of pure quartz, and others.

Therefore, although no one has yet feen thick ftrata, or huge heaps of magnefia, yet it is formed in a perfect ftate upon the furface of the earth; and the chymical analyfis of earths and ftones difcovers it, partly mixed mechanically with other matters, partly diffolved;—neither its quantity nor bulk can change the nature of the thing itfelf: we are forced to give up fuch tranfmutations as not only being fallacious, and not founded upon fufficient experiments, but as contradicting each other:—for fome pretend that magnefia is produced from lime, others from clay, a third from the earth of alum, and, what is obfervable, that this may be done by the vitriolic acid. But we are not enquiring what may poffibly be done, being intent on difcovering what plain experiments fhew to have been actually done.

§ xxi. *The Ufes of Magnefia.*

Magnefia has hitherto been only ufed in the apothecary's fhop; and it acts in a different way, according as it is crude, or calcined, or combined with an acid:—when

10   crude

crude it deſtroys acidities in the *primæ viæ*, but at the ſame time giving out its aerial acid, occaſions in ſome perſons conſiderable inconveniences (*v*). It accelerates the putrefaction of fleſh more than chalk, crabs-claws, or the other teſtaceous powders; but retards that of the bile (*u*).

Half the doſe of calcined magneſia equally opens the bowels, and deſtroys acidity, and that without any inconvenience. It not only preſerves fleſh long, but in a ſingular manner reſtores bile already corrupted: taken in equal proportions, with camphor, opium, guaiacum, ſtorax, maſtic, aſſafœtida, myrrh, ſcammony, and other gum-reſins or pure reſins, and triturated with water, it yields very uſeful tinctures; for upon filtration they appear clear and ſaturated, without any thing cauſtic, as calcined magneſia refuſes to diſſolve: but theſe tinctures muſt be only made when wanted.

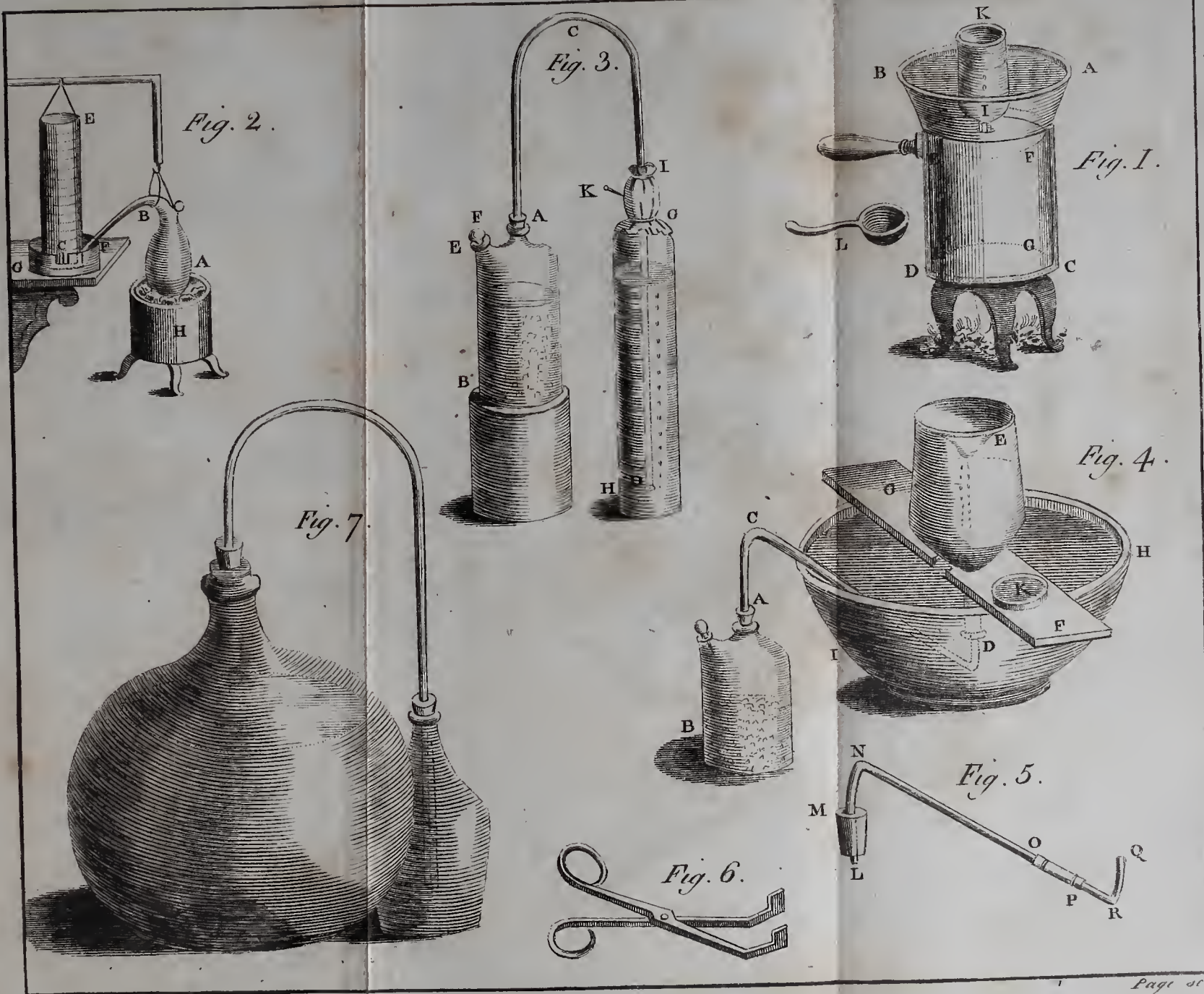Every one knows the cathartic uſe of vitriolated magneſia.

The uſe of magneſia in rural œconomy muſt be left to the examination of manures.

(*v*) Quandoque flatulentias et morſicationes in imo ventre relinquit, ſi frequentiùs in uſum trahitur, primaque regio, progignendis corroſivis ſuccis, ut in hypochondriacis fieri ſolet, expoſita eſt.

(*u*) Henry on Magneſia.

END OF THE FIRST VOLUME.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 8.

Fig. 7.

Fig. 9.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 2.

Fig. 3.

Fig. 1.

Fig. 4.

Fig. 7.

Fig. 5.

Fig. 6.

COMPARATIVE VIEW of the FRENCH and SWEDISH THERMOMETERS with that of FAHRENHEIT.

Fahren-heit.

Reau-mur.

Swed-ish.